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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

FEBRUARY 1960

SPECIAL SECTION
ON SPACE HOLDING FACILITIES

How Useful Are Low-Thrust Space Vehicles? . . . Ernst Stuhlinger
High-Thrust Space Vehicles . . . . . M. W. Hunter and J. M. Tschirgi
Open Letter to Amateur Rocketeers

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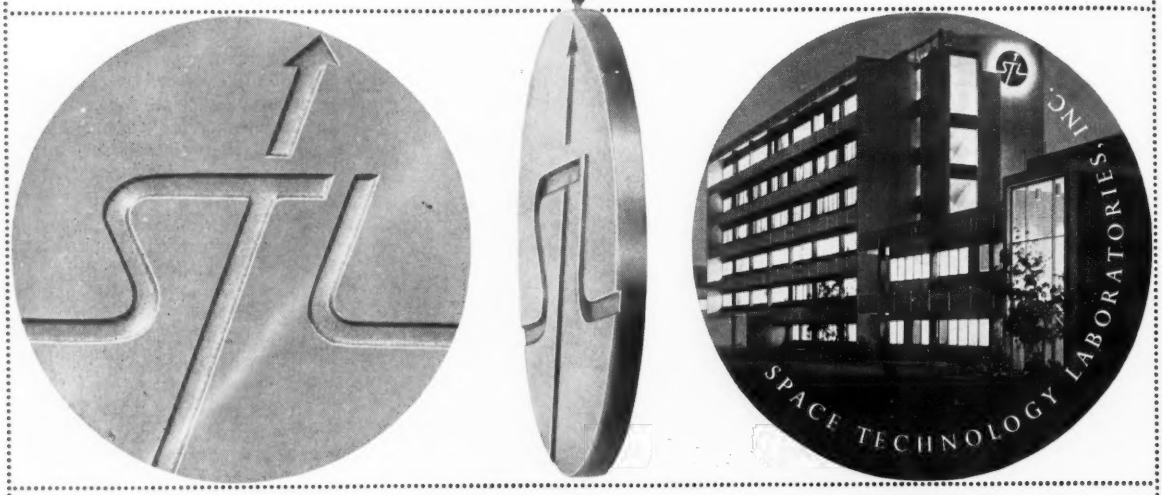

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Astronautics

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February 1960 volume 5 number 2

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EDITORIAL

23 Ardent Youth . . . . . *Howard S. Seifert*

SPACEFLIGHT

24 How Useful Are Low-Thrust Space Vehicles? . . . . . *Ernst Stuhlinger*

28 Advantages of High-Thrust Space Vehicles . . . . . *M. W. Hunter and J. M. Tschirgi*

SPACE HOLDING FACILITIES

32 Background to the Spacecrew Holding Facility . . . . . *Major Julian E. Ward and J. Gordon Wells*

34 The Flight Surgeon and the Astronaut . *Toby Freedman*

36 Psychological Problems of Selection, Holding, and Care of Astronauts . . . . . *Siegfried J. Gerathewohl*

38 The Role of Simulators for Spacecrew Training . . . . . *Gordon A. Eckstrand and Marty R. Rockway*

40 The Physiologist and the Holding Facility . . . . . *Lt. Bruce W. Pinc*

42 Spacecrew Epidemiology . . . . . *Col. Fratis L. Duff and Col. Thomas A. Collins*

INTERNATIONAL SPACE COMMITTEES

27 Two Permanent International Space Committees Set Up . . . . . *Irwin Hersey*

AMATEUR ROCKETRY

30 Open Letter to Amateur Rocketeers . *Peter Zimmerman*

43 Edroc—Educational Rocket Motor . . *Richard Hanbicki*

DEPARTMENTS

4	Astro Notes	72	Patents
12	For the Record	83	People in the News
16	Mail Bag	86	Materials Data Sheet
20	International Scene	92	Missile Market
56	ARS News	98	In Print
60	On the Calendar	104	Contract Awards
70	Propellants Data Sheet	107	New Products

110 Index to Advertisers

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Astro notes

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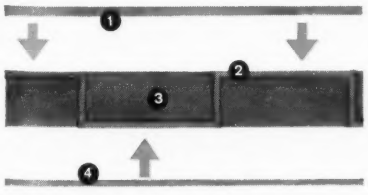

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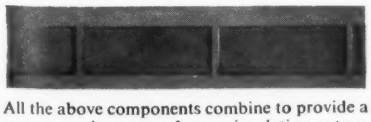

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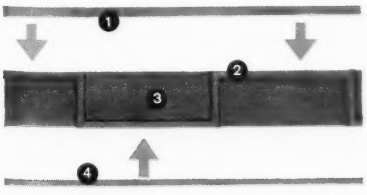

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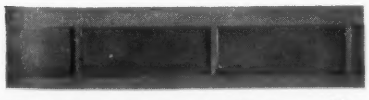

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1957 and early 1959. One was a woman reportedly killed in a Soviet "space aircraft," while the others were killed in rocket mishaps or were lost in space. Washington officials pointed out inconsistencies (one rocket had a burning time of 20 min; two different launching sites were confused, etc.) and noted that the Russians have no worldwide tracking system.

• The announcement by the U.S.S.R. that it would launch rockets over a 6000–8000-mile range to a target area about 1000 miles east of the Marshall Islands in the Pacific came as another blow in the space race. According to the Russians, the tests will involve rockets for launching heavy earth satellites and probes to other planets.

• Speculations on the purpose of the Russian tests were rife in Washington and the news services . . . Russian Dynasoar, Russian Saturn, Russian super booster, Russian man in space, etc. A fair guess might be that the Russians are prepared to test a clustered version of the rockets used in their satellite and probe launching vehicles.

• For what it's worth, last October, *Pracovnik Svazar Mu*, published in Prague, quoted A. Topchiev, vice-president of the U.S.S.R. Academy of Sciences, as saying, "Following the second Soviet cosmic rocket, man is to be the next visitor to the surface of the moon." According to its article, Russia is already working on a single-stage rocket with a thrust of more than 1.5 million lb. Twenty of these, it goes on to say, could equip a five-stage space vehicle capable of taking two or three men in a two-story vehicle to the moon and back to earth. The article did not attribute other than Topchiev's statement to anyone.

NASA

• T. Keith Glennan is scheduled to ask Congress for a supplemental appropriation for the current fiscal year, in part to meet unexpected costs in Project Mercury. The U.S. man-in-space program will require an investment of $152 million by June 30, $24 million more than originally planned. The extra money, necessary for more extensive telemetry and data display in the Mercury tracking program, was transferred from R&D funds for the advanced Mercury program (18-orbit mission and rendezvous studies) and from other accounts.

• Included in the additional Mercury tracking facilities, NASA told the Senate Space Committee, are transportable tracking radars to be installed on Bermuda and the West Coast of Africa for use in the event an abort takes place during launching, another transportable tracking radar for the West Coast of Australia for more precise positioning on this portion of the orbit and for timing of the retrorocket and the capsule recovery point, and a tracking radar in West Central America to locate the capsule if it must reenter after only one orbit.

• NASA will probably undertake two more Atlas-Able shots at the moon this year, according to close observers of the agency. Although no decision has been reported, the decision to cancel Vega has postponed still further the time when the U.S. will have a fully-guided three-stage rocket system for large, accurate probes to the moon and planets. (The two-stage Atlas-Agena will only be useful for large satellites, although in a pinch it could send small payloads to the moon; Atlas-Centaur isn't due until 1962.) Thus Atlas-Able will be the only U.S. rocket capable of lunar missions during the long dry spell before Centaur. Despite these hard facts, however, some NASA officials remain convinced that resort to Atlas-Able for such missions is "sending a boy to do a man's job," with disappointments more likely than successes.

• NASA canceled its December firing of the Venus-orbit shot because of checkout difficulties. It was rescheduled for January, but scheduling difficulties at Cape Canaveral threatened to delay the attempt until February. Last of the "Paddlewheels," the 90-lb satellite is to be fired into a 295-day solar orbit with its perihelion intersecting the orbit of Venus. It will have a solar-powered 150-watt transmitter to send its signals across the distance of 52 million miles between it and the earth when it crosses the orbit of Venus. A major scientific result of the shot would be a more accurate fix on the Astronomical Unit mean distance from Sun to Earth), now known to roughly plus or minus 50,000 miles. This information will be vital for future interplanetary probes.

ASTRONAUT INSURANCE

• The Astronauts would receive a government-paid insurance policy for $100,000 through a House bill submitted by Congressman E. Q. Daddario of Conn. Travelers Insurance has shown a willingness to insure the Astronauts, according to Daddario; and the Constellation Life Insurance Co., Norfolk, Va., in cooperation with American United Life of Indianapolis has offered the Astronauts life insurance in the amount of $20,000 at regular rates, according to "The Eastern Underwriter."

SPACE SCIENCE

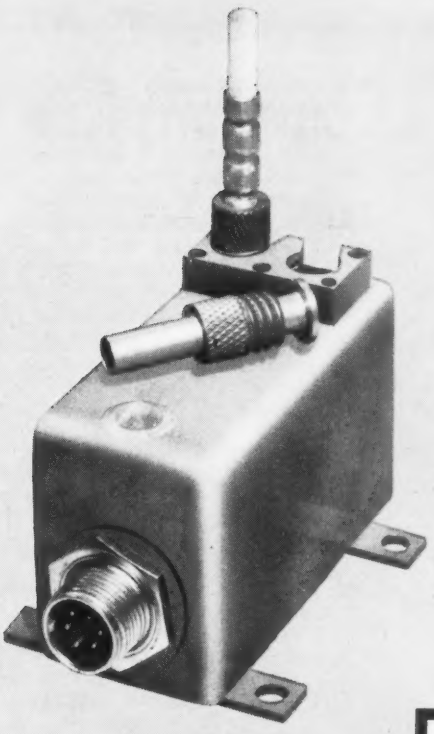
• The Navy was scheduled to launch three colossal balloons from the flight deck of the carrier Valley Forge in the West Indies at the end of January to trap primary cosmic rays. With a capacity of 10 million cu ft of helium, the balloons will measure 400-ft in diameter, and will be able to carry an 800-lb stack of photographic emulsions to an altitude of 120,000 ft for a period of 48 hr. An interesting feature of the operation is the plan to inflate and launch the mammoth balloons on the carrier deck. To accomplish this, the carrier will head downwind at a speed just sufficient to cancel out all wind effects. The wind, however, must be steady and less than 10 knots.

• Mathematicians of NASA's Goddard Space Flight Center have calculated that careful selection of the launch times of high-apogee satellites like Explorer VI can result in an increase of perigee at a rate of 1 km a day for several years after launching. This boost in perigee can be supplied by the gravitational effects of the sun and the moon. Conversely, times of day can be selected for launching eccentric-orbit satellites which will lose perigee altitude at the same rate.

• The earth is accompanied around the sun by a relatively cool (1000–2000 C) bank of hydrogen which filters out the Lyman Alpha radiation of the sun, according to Richard Tousey of the Naval Research Laboratory. Discussing an Aerobee-Hi fired from White Sands, N.M., last July, which photographed Lyman Alpha line in the ultraviolet, Dr. Tousey said there would appear to be some 10^{12} hydrogen atoms in every column of 1 sq in. between the earth and sun. It is believed most of these hydrogen atoms come from the earth itself, i.e., from marsh gas and water vapor which are broken down at high altitude by sunlight, thus releasing atoms of hydrogen, which then form a sort of satellite cloud around the earth.

• Data from Explorer VII backs warnings of several scientists, including Navy Balloonist Malcolm

Mc/S/A



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Model IV

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- Improved R.F. and stray voltage safety.
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- Meets missile qualification requirements.
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- Series parallel explosive train for maximum reliability.
- No moving parts during arming and safing.
- No primacord expulsion or cut-off.
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FIRING AND ARMING CHARACTERISTICS

Arming,	26 $^{+4}_{-2}$ volts D.C. at 50 ma.
All fire,	24 volts D.C. min. 2.3 amps D.C. min.
No fire,	15 volts D.C. max. 1.0 amps D.C. max.

The Model IV Safe/Arm Initiator has been developed under a new and advanced design concept. Arming or safing is accomplished with no moving parts by charging or discharging self-contained capacitors. Application of firing signal sequentially aligns and initiates the explosive train.

Various models can be supplied for checkout and initiation of rocket motor igniters, high explosive charge, pyrocore and mild detonating fuse.

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EXPLOSIVE ORDNANCE

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Ross, that man in space will be bombarded with sudden sporadic bursts of radiation. Thought associated with solar disturbances and resulting geomagnetic storms, the bursts have not yet been identified exactly as to cause or intensity. Of three detected by Explorer VII, one occurred between the so-called layers of the Great Radiation Belt and two occurred on its inner boundary.

MISSILES

• The Navy is seeking funds for an air-launched antisatellite weapon. Dubbed NOTSNIK (for the Naval Ordnance Test Station at China Lake, Calif.), the proposal is an outgrowth of earlier Navy efforts to launch small satellites from a jet aircraft using a multistage 2500-lb solid rocket. Three attempts were made in 1958 but none were believed successful. Another antisatellite study is the Air Force's Silver Saint. Both may be funded by ARPA, which got $17.6 million this fiscal year to conduct upstream work on antisatellite and antimissile weapons.

• Despite its development headaches, Titan remains solidly in the Air Force's ICBM program. Two years ago, or even last year, the Air Force might have dropped Titan and ordered an all-Atlas force with no delay in meeting force goal deadlines. "Now we're committed," said a top USAF official, "we've got to bring it along no matter what." He added that recent Martin management shifts on the Titan, including the transfer of Chairman George Bunker to Denver to take personal charge of the Titan, reflected an Air Force desire to tighten up the whole program and end the series of trivial but costly goofs which have damaged and destroyed test missiles and delayed the flight-test program.

• The Navy has given Martin a $22,800,000 contract for additional production of Bullpup missiles, incorporating Thiokol's new prepackaged liquid rocket engine, the LR58-RM2. The Bullpup is an air-to-surface missile weighing 571 lb. and measuring 11 ft in length. It can deliver a 250-lb warhead approximately 3 miles.

• Autonetics Div. of North American has received a $115,020,000 contract for continued development, fabrication, and test of inertial guidance and flight control systems for the Minuteman ICBM. A key requirement of the system is that it remain operable for long periods of time in hardened underground silos without human maintenance.

• Aircraft and missile producers will sell more than $10 billion worth of products in 1960, according to a forecast by the Aerospace Industries Assn., with military orders accounting for more than 80 per cent of the total. Research and development spending will increase, while large orders and long production runs will continue to shrink. "The increasing trend toward research and development contracts will continue to adversely affect the rate of earnings of the aerospace industry," AIA observed.

• By and large overlooked in recently released testimony was an Army general's statement that Nike-Hercules successfully destroyed a Pogo-Hi target rocket at an altitude of 150,000 ft. The general had the films to prove it. The test took place last year at White Sands, N.M. As for the Nike-Zeus anti-ICBM weapon, the first partial test is not expected until 1961 and the complete system test (with Jupiter warheads as targets) will not come until 1962 in the Pacific.

• The U.S. Marine Corps has ordered 100 Cobra wire-guided antitank missiles from Daystrom, Inc., for evaluation. Developed by Boelkow Entwicklungen of Munich, Germany, the weapon weighs only 20.2 lb, and its control unit only 4.4 lb. It has a powered velocity of 191 mph, a powered range of 1 mile, a burning time of 18 sec, and a 5.5-lb warhead capable of penetrating 21.5 in. of tank armor, Daystrom said.

• Although the Air Force has requested (and probably will receive) funds to carry on its truncated B-70 bomber development program, top USAF officials frankly admit there is little prospect any new money voted for the Mach 3 machine will actually be put on contracts. "Barring unforeseen developments, the B-70 insurance premium will be completely paid up by next summer," a USAF official said privately. He was referring to a theory that the B-70's principal purpose to date has been insurance against a sudden failure of the missile programs.

• A number of factors militated against the B-70 besides the inevitable problem of funds. The time required to get an appreciable number of B-70's into operation was deemed excessive. Operating at Mach 3 and with a skin temperature of more than 600 F, the aircraft would light up the sky for IR-homing missiles. And the bomber's operational altitude (70,000 ft) would favor nuclear-tipped defensive missiles, since their fireballs would be much greater in the reduced atmospheric pressure.

• The decision to "reorient" the B-70 renders it virtually certain that the Air Force will undertake the development of a 1000-mile-range version of the airbreathing Hound Dog. The present models have a 500-mile range. The B-70 decision also brightens the outlook for a 1000-mile-range Air Launched Ballistic Missile (ALBM). Both weapons would be carried by the B-52 and should materially extend its operational life.

SATELLITE SQUAD

• The Air Force has unobtrusively formed the 6594th Test Wing, a unit devoted exclusively to the operation of artificial satellites. It has been training in the Discoverer project.

FAR EAST

• Building on its work with the Kappa-7 rocket (6.7 meters long and 42 cm in diam), Tokyo Univ.'s Production Technique Research Laboratory hopes to produce a two-stage Kappa-8, which could reach an altitude of 100 km, and test it this spring. If successful, this rocket would be given another stage to form Kappa-9, Japan's bid for a homegrown satellite launcher.

• With Russian technical assistance, Red China should be able to launch its first satellite within two years, according to U.S. intelligence sources.

R&D

• Metallurgists at NRL have developed a zinc-based coating for columbium alloys that maintains the properties of the alloys at temperatures up to 2200 F in an oxygen atmosphere. The zinc alloys with the columbium and releases gradually to form a surface layer that blocks oxygen and rapidly covers any flaws in the base alloy. Plastic and ductile at high temperature, the surface also prevents bare spots from developing when the base metal is stressed.

• Thiokol's Reaction Motors Div. has reported good progress on hybrid engines being developed under Air Force Contract.

• Callery Chemical will produce

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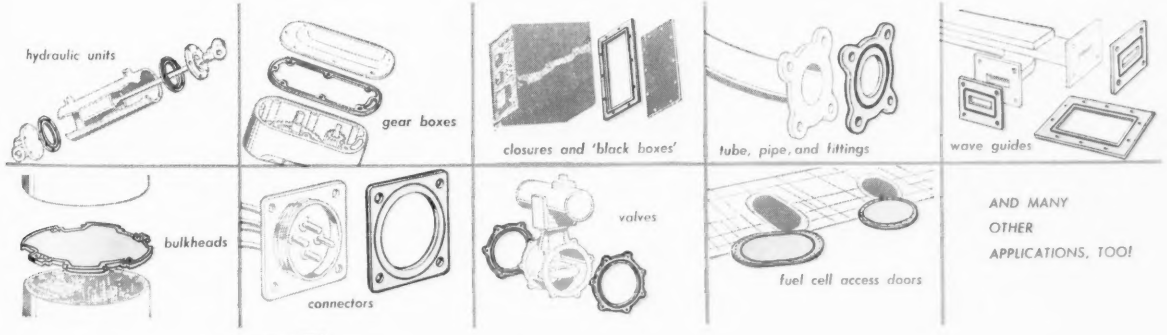

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high-energy propellant at its Muskogee (Okla.) plant for the Air Force.

• Texas Alkyls (owned by Hercules Powder and Stauffer) and Ethyl Corp. both now have plants producing more than a million pounds of aluminum alkyls a year.

• This month should see the first flight-testing of American Bosch Arma's inertial guidance in Atlas. The inertial system, checked by telemetry, will fly tandem with the GE/Burroughs ground-command system in the first tests.

• Proposals on the 300-kw, closed-cycle nuclear-powered generator for space vehicles are due in to WADC this month. The Air Force has required that proposals show a growth potential to 1000 kw over a five- or six-year period.

• A static-testing installation for evaluating high-energy liquid propellants, such as liquid fluorine, boranes, and halogen hydrazines, has been started by Aerojet-General at its Liquid Rocket Plant in Sacramento, Calif.

• General Electric exhibited some of its development work on the thermoplastic recording process (TPR) devised by William E. Glenn of its Schenectady Research Laboratory. The process involves the freezing of information laid down with an electron gun on the surface of a special three-layer thermo-plastic tape. The technique at present can handle 40 million bits of digital information per sq in. of tape surface. Able to receive, store, and redeliver even a full-color image, and to record, readout, and accept erasures with great speed, TPR promises to have important military, domestic, and space applications (such as data storage in a weather satellite). Experimental TPR equipment will be delivered to the military within a year, according to GE. *The Journal of Applied Physics*, vol. 30, no. 12, carries Dr. Glenn's description of the basic process.

• Russian studies indicate that plastics may be usable as semiconductors, with excellent properties at high temperatures.

• NASA'S Lewis Research Center has operated a cesium-ion engine for more than 50 hr, according to J. Howard Childs, head of its Electric Propulsion Branch. There has been speculation that an ion engine will be launched in a satellite for development trials within the next couple of years.

• President Eisenhower's statement that Atlas had achieved a mean circular error (CEP) of less than 2 miles in 15 shots of more than 5000-mile range indicates that the missile has pulled through development with both high reliability and accuracy. This is welcome news, in view of the worrisome technical failures that plagued Atlas early last summer, and vindicates the Air Force-Convair view that problems with the missile could be remedied promptly.

• Most people seem to have missed the chief conclusion of the Pendray and Co. report to the Daniel and Florence Guggenheim Foundation titled "Technical Meetings in the Flight Sciences." To quote: "After careful reading of the programs of eight major societies in the flight sciences, and detailed comparative study of the programs of four of these societies for the year 1958, we have come to the conclusion that there is relatively little, if any, overlapping of specific subject matter in the meetings of these societies."

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Scientists and engineers in universities, government establishments, and industrial laboratories will find significant reference points in the various theories, experimental techniques, and applications presented in the Proceedings of the Third Biennial Gas Dynamics Symposium—held August 1959 under the joint auspices of the American Rocket Society and Northwestern Univ. Papers herein cover the physics of plasmas, magnetogasdynamics, plasma phenomenology, and engineering applications associated with conducting gases.

The publication, containing 224 pages, including 190 illustrations, will sell for $12.50. Publication date is March 15th.

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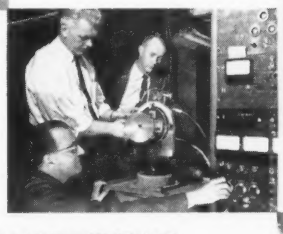

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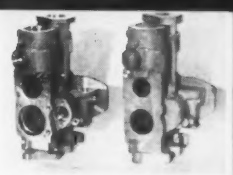

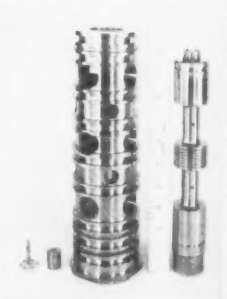

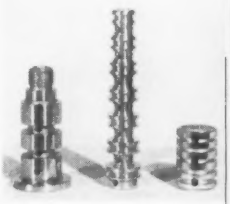

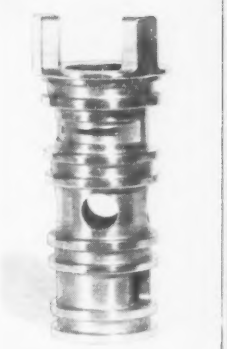

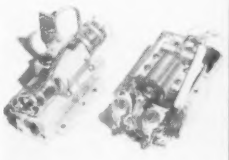

For the record

The month's news in review

Dec. 1—Thomas S. Gates Jr., former Navy Secretary, becomes Defense Secretary.

—AF discloses that, for the time being, it will produce only one or two test models of the B-70.

Dec. 2—DOD says it will conduct a series of anti-missile tests, involving nearly $100 million worth of detection equipment, in the Pacific area in late 1961 or early 1962.

—Glenn T. Seaborg, discoverer of plutonium, is awarded the $50,000 Enrico Fermi Award.

Dec. 3—AF is reported considering design competition for VTOL jet.

Dec. 4—NASA launches a monkey named Sam 55 miles into space and returns him alive, in test of Mercury emergency escape mechanism.

Dec. 5—Army announces successful test-firing of French SS-11 wire-guided missile from helicopter.

Dec. 6—NASA discloses plans to launch first of three Project Echo inflatable spheres next spring in attempt to set up global radio relay station.

—Pratt & Whitney reports successful test-firings of XLR-115 liquid hydrogen engine to be used for Project Centaur.

—NASA reports Explorer VII's 108 mc transmitter is silent.

Dec. 7—AF announces new solid-propellant rocket tagged Jaguar for upper atmosphere probes.

—NASA offers U.S.S.R. use of our worldwide tracking facilities for Soviet man-in-space projects.

Dec. 8—Aerojet announces development of variable-thrust liquid rocket engine.

—AF fires Atlas 5500 miles.

Dec. 10—James H. Douglas, AF Secretary, is named Deputy Secretary of Defense, with Dudley C. Sharp succeeding Douglas.

—NASA discloses that Project Mercury "has been assigned the highest national priority" and plans to spend $150 million more than the previously estimated $200 million on the project.

Dec. 11—NASA cancels Vega program.

Dec. 12—AF Titan explodes on pad.

—UN creates permanent 24-nation committee, to study peaceful use of outer space.

Dec. 14—Administration announces it will ask Congress for $800 million for national space program for fiscal 1961.

Dec. 16—Nike-Zeus second stage fails to ignite in Army test-firing.

Dec. 20—Navy and NSF announce plans for joint Operation Skyhook launchings in late January.

Dec. 22—U.S.-Canadian team fires four-stage Javelin rocket with 48-lb payload to study radio noise from space. Experiment also provides test of X-248, inexpensive solid-fuel rocket engine.

Dec. 23—Navy destructs Polaris seconds after launching from ship motion simulator.

Dec. 27—NASA proposes joint space shots with other nations in effort to promote international cooperation in space research.

Dec. 28—Wallace R. Brode, scientific adviser to State Dept., calls for establishment of Federal Science Dept.

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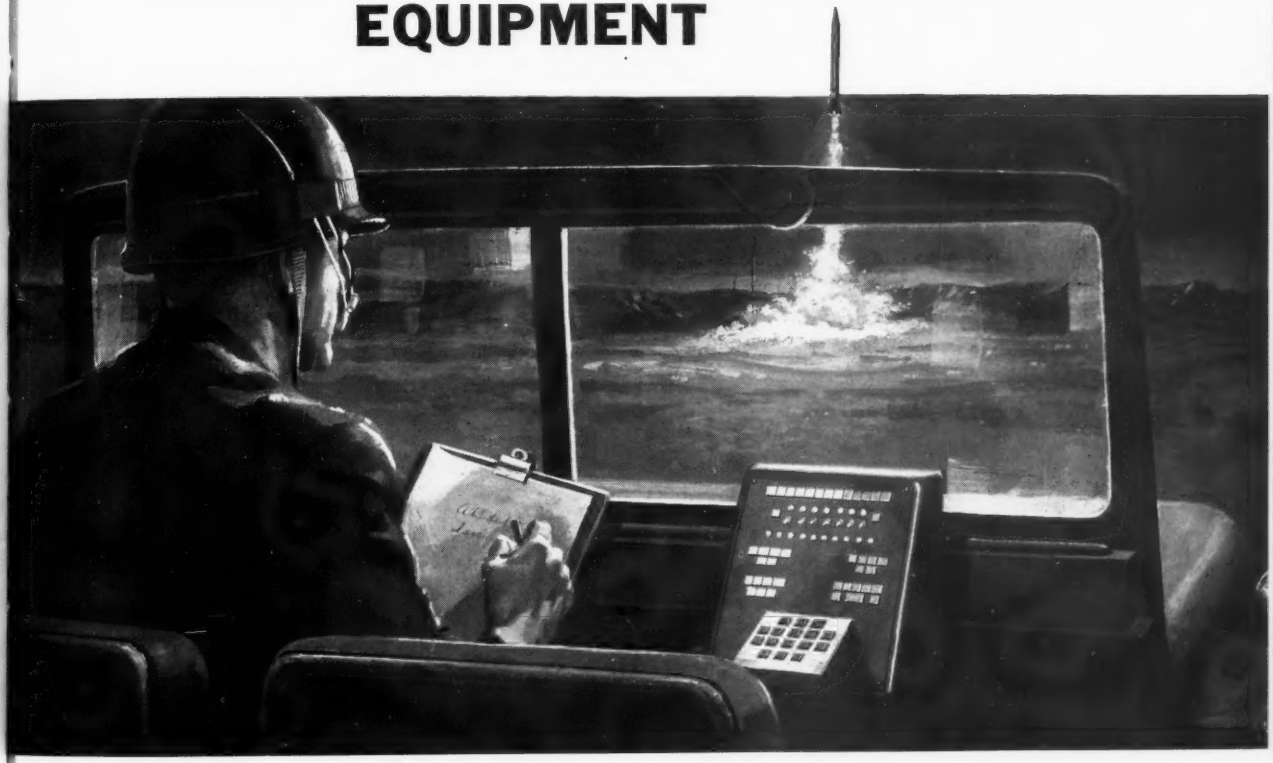

The micro-module is a new dimension in military electronics. It offers answers to the urgent and growing need for equipment which is smaller, lighter, more reliable and easier to maintain. Large scale automatic assembly will bring down the high cost of complex, military electronic equipment. Looking into the immediate future, we see a tactical digital computer occupying a space of less than two cubic feet. It will be capable of translating range, wind velocity, target position, barometric pressure, and other data into information for surface to surface missile firings. The soldier-technician monitoring the exchange of computer data will have modularized communications with the other elements of his tactical organization. RCA is the leader contractor of this important United States Army Signal Corps program and is working in close harmony with the electronic components industry.

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Space Age Milestone!

Man's flight into outer space drew nearer with the successful re-entry of NASA's "Big Joe" test capsule controlled by a Honeywell Stabilization System

The guidance system for this capsule, launched by an Atlas missile, was provided by Honeywell—and it was delivered in less than half the time usually required for projects of this scope.

Rapid delivery was possible because the basic components necessary to accomplish this sensitive and exacting task were on-the-shelf or in production at Honeywell. However, two critical jobs remained to be done. One was the task of designing a package for these components which would be rugged and exact enough to do the job; and the other was that of providing the ground support for system check-out and pre-launch monitoring. Both of these difficult objectives were completed in the time allowed.

This electronic stabilization and control system is designed to provide a reference that permits measurement of the capsule's attitude and rate of motion. By operating the on-off valves for the reaction control nozzles, it dampens any oscillatory tendencies of the capsule and eliminates the possibility of tumbling.

The design and delivery of this system, the first of six such Honeywell systems for NASA Mercury capsule test shots, is in keeping with the accelerated man-in-space program and is typical of Honeywell's ability to meet both stringent requirements and critical deadlines.

Final check of attitude stabilization control system for flight and re-entry control of "Big Joe" test capsule is made by a Minneapolis-Honeywell technician prior to delivery.

This readiness for the space age stems both from Honeywell's established policy of supporting the national defense and from the company's own historic areas of interest. For further information concerning Honeywell's capability in space age projects, write Minneapolis-Honeywell, Aeronautical Division, Dept. 671, 2600 Ridgway Road, Minneapolis 13, Minn.

Honeywell

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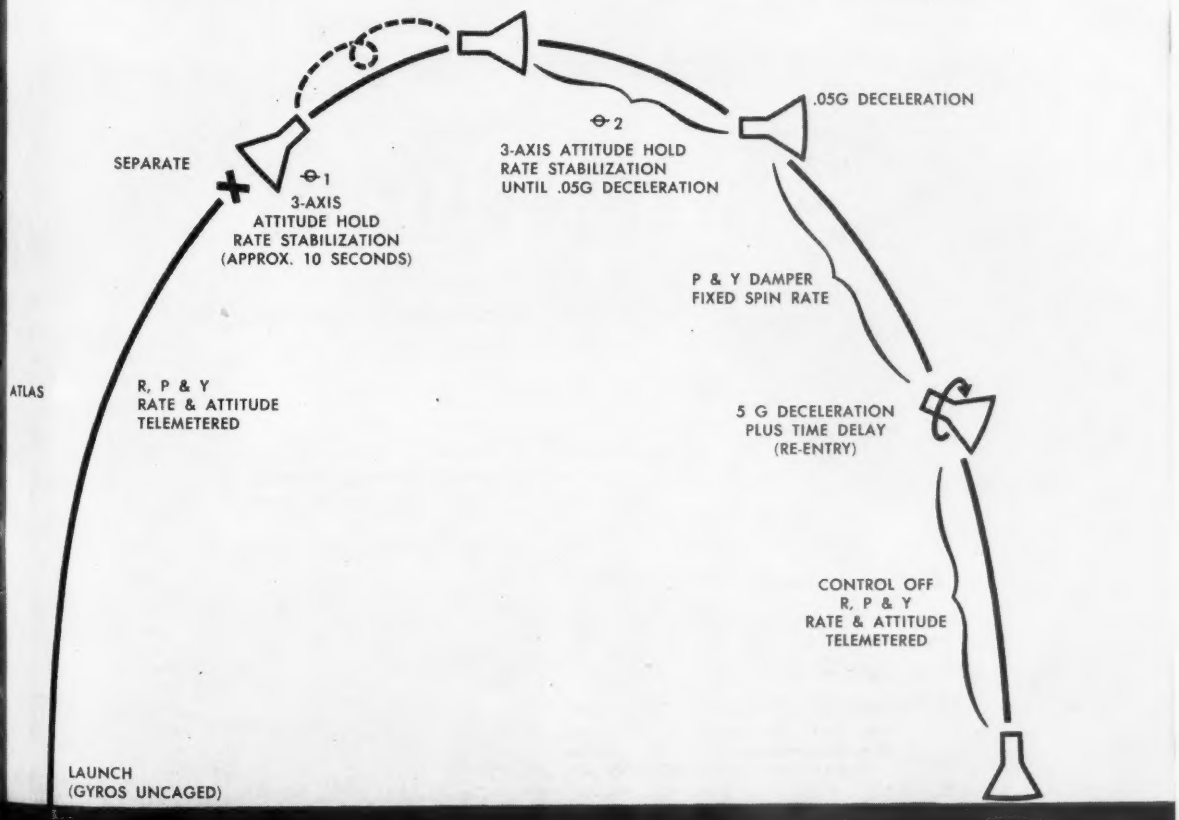
The Honeywell "Big Joe" Control System assumes control at separation and immediately provides a three-axis attitude hold, rate-stabilized mode to maintain the separation attitude (Θ_1). Approximately ten seconds later, it programs the capsule to a new attitude (Θ_2), and maintains this attitude until .05g deceleration is sensed, indicating that re-entry is commencing. Upon sensing .05g deceleration, attitude hold shuts off, pitch and yaw rate stabilization are maintained, and the capsule is commanded to spin at a 6°-per-second rate until deceleration increases to 5g. At this point control ceases. With attitude reference control deleted, the blunt end of the capsule slowly turns into the flight path due to its aerodynamic static stability. The rate gyro control dampens any tendency to tumble, yet permits the capsule orientation to move as required to keep the heat-resistant blunt end leading. Pitch, roll and yaw attitude, as well as rate signals, are telemetered from takeoff to touchdown.



Mail bag

More on the Moons of Mars

Sirs:

I have read with interest the exchange between Shklovsky and Tombaugh in the December *Astronautics*. . . Shklovsky, of course maintains that the only way to explain the peculiar motion of the Martian satellite Phobos is to assume that it is hollow, and that therefore it has been manufactured, presumably by Martians.

The reply by Tombaugh, who doubts that the Martian moons are anything but natural bodies, contains much pertinent information but fails to convince me. I agree with the interesting discussion about the albedo of the satellite and the fact that their diameters may vary by factors and be either larger or smaller than Shklovsky assumes, but this would not change the situation very much. Instead of being 20 cm thick as Shlovsky concludes, the satellites might be 15 cm thick, or 30, but they would still be hollow.

The two main objections of Tombaugh I find not to be very relevant. The fact that the Martians would go broke if they put up these two multimillion-ton satellites doesn't impress me as a counter-argument. Maybe this is *why* they have ceased to exist. But seriously, one could argue that the building of the pyramids should have overstrained the Egyptian economy. Nevertheless, the Egyptians did put them up. At least there has been no serious question raised about this.

The second argument, namely that the physical conditions on Mars are unfavorable to the development of a species capable of achieving a high technology, again is not convincing, because, if such beings are ever found, we might equally well prove that conditions on Mars are favorable.

The real meat of Tombaugh's objections, I think, lies in his arguments that the Martian satellites are not as unusual as Shklovsky claims—that Jupiter has very tiny satellites and that the fifth satellite of Jupiter has a very short period of revolution close to Jupiter's own rotation period.

On the other hand, the real point on which Shklovsky's argument is based is that the satellite finds itself 2.5 deg from the point where it should be, and he takes this as evidence for a large influence of atmospheric friction on the satellite. To this point Tombaugh argues that perhaps a large density of dust could produce the same effect. It seems to me that this does not change the argument at all. Even if the dust drag is ten times as important as the atmospheric drag, then Phobos might be 40 cm thick, but it would still be hollow.

My conclusion therefore is, and here I back Shklovsky, that if the satellite is indeed spiraling inward as deduced from astronomical observations, then there is little alternative to the hypothesis that it is hollow and therefore Martian-made. The big "if" lies in the astronomical observations; they may well be in error. Since they are based on several independent sets of measurements taken decades apart by different observers with different instruments, systematic errors may have influenced them.

I would be very disappointed indeed if the satellites of Mars turned out to be solid and not artificial. It is quite evident to me that if they were made by the Martians, their purpose naturally would be to sweep up the radiation belts around Mars so as to enable Martians to operate without radiation hazards in the vicinity of their planet. I have calculated that the sweeping effect of the Martian satellites should be very noticeable and should be easily detectable with a suitably designed experiment in a Martian probe. Because of the sweeping effect and also because of its low gravitational potential, Phobos would make an ideal space base for manned exploration of Mars, not only for Martians but also for us Earthlings.

S. F. Singer
Physics Department
Univ. of Maryland
College Park, Md.

Praise for ARS Publications

I have recently become a member of the AMERICAN ROCKET SOCIETY and have been impressed with the excellent journals published by the Society, in particular the monthly issues of *Astronautics*. As a matter of fact, I was primarily attracted to membership in the AMERICAN ROCKET SOCIETY by reviewing the Society publications.

There were several issues earlier this year that would be extremely valuable to me and I would like to inquire whether it would be possible to obtain the past issues starting with January of this year 1959 through September 1959. I would appre-

(CONTINUED ON PAGE 71)

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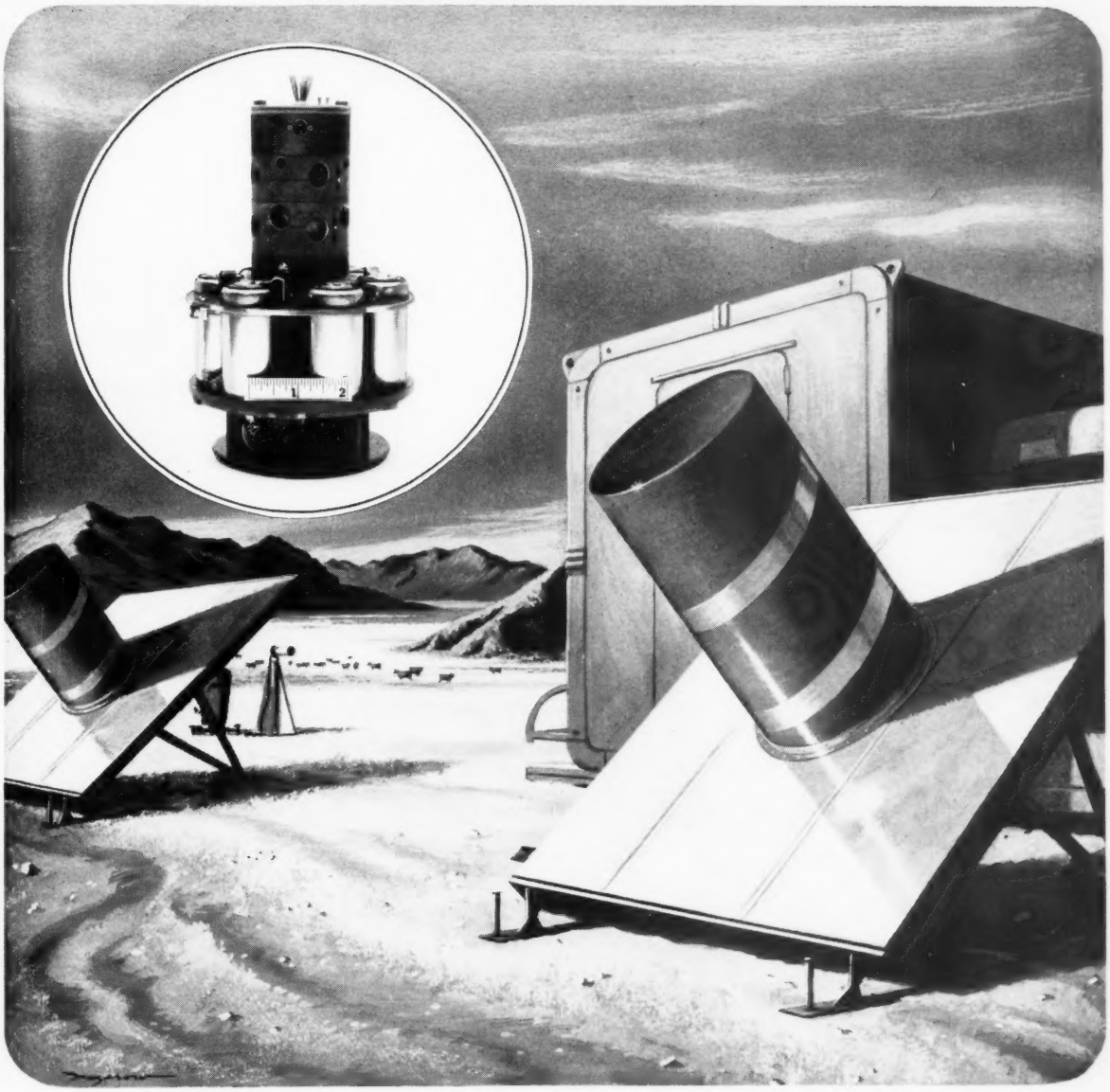

From MICROLOCK to microlock

One of the most interesting and useful scientific activities at JPL has been the development of MICROLOCK, a radio tracking and communication system for satellites.

Microlock is designed to transmit information over extreme ranges of space with a minimal amount of transmitter power and weight. The objective was achieved by sophisticated design of the ground receiving equipment. The design utilizes basic electronic circuits and techniques carefully combined in a novel manner to provide superior performance and sensitivity.

The satellite transmitter consists of a radio-frequency oscillator, phase-modulated by telemetering signals, and radiates a power of 3 mW. It is capable of operating for several months on a battery weighing one pound.

Used successfully in previous space vehicles, microlock remains a useful and expandable instrument for continuing space exploration. It is a prime example of JPL's activity on the space frontier.

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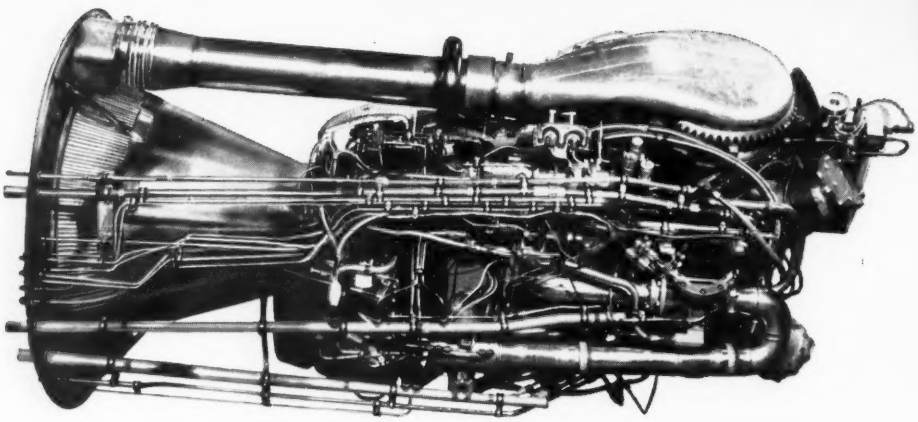

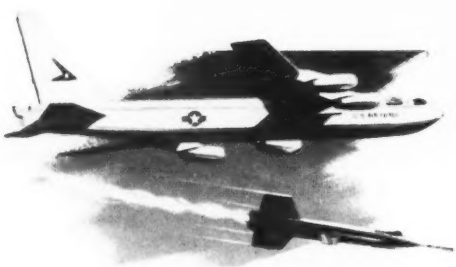

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International scene

By Andrew G. Haley

Chinese Astronautical Research—Part 1

When writing about astronautical research and development activities in the Communist countries, this column has steered clear of idle speculation and educated guesses. The slowness of the mails and unavoidable delays in obtaining good translations of certain interesting publications and articles has, unfortunately, prevented the compilation this month of an informed report on present astronautical efforts in the People's Republic of China (Peking) or the Republic of China (Taipei, Taiwan).

Consequently, it was thought advisable to begin this survey of Chinese astronautical research with a brief survey of evidence available outside the two countries which indicates the direction such research is taking.

° ° °

In the course of countless conversations in Moscow, Warsaw, Prague, Belgrade, Sofia, New Delhi, and several other cities in Eastern Europe and elsewhere during the past two years, for example, the author was frequently told of the great efforts being made by the Chinese race as a whole, and mention was often made of the ages-old Chinese scientific genius, exemplified in our own field by the contribution of the rocket itself and, even more important, of the matrix of astronomical learning. Perhaps the least of the Chinese efforts today has resulted in the remarkable physical facilities already built and being built by the Chinese Communist government.

As a result of these conversations and observations, certain reasonable conclusions may be derived, but the danger always exists that authentic conclusions will degenerate into undisciplined guesses. One may now examine some of the evidence.

In Moscow, Leningrad, Warsaw, and Prague, in particular, and indeed in other cities as well, the writer has seen placard displays from Communist China—and by the term "placard" is meant all forms of visual displays, from tiny pictures to huge posters. It is difficult to remember any activity of life not covered by these placards and posters. There are many on safety education; a whole series illustrating labor-saving devices; hundreds featuring books and periodicals and providing omnibus coverage of mathematics, physics, chemistry, economics, history, literature, biology, geography; still others showing pictures of great public works, including the building of railroads, highways, hydroelectric projects, and great new cities such as Lanchow, the newly created educational and scientific metropolis in Kansu Province in the center of China.

After viewing hundreds and hundreds of these placards and posters, a mental montage is created, leaving a central impression for each individual in accordance with his principal interest in life. For one example, the safety engineer will remember the constant recurrence of safety education, and so on. The writer was impressed with the constant occurrence of astronautical subjects—submerged launching sites in high mountains; formidable-looking missiles mounted on mobile chassis; gantry cranes at open launching sites; pressurized spacesuits; and other familiar artifacts of the Space Age. From this, one can legitimately conclude that the Chinese Communists are actively interested in astronautics and that a multitude of astronautical programs are underway.

° ° °

During visits to Eastern European countries, the writer often inquired about an old Chinese-American friend, H. S. Tsien, who returned to China in 1953. Many of the scientists of whom the writer has made inquiry know Dr. Tsien personally, and apparently there is no great secret surrounding his astronautical activities in Communist China. Dr. Tsien was very well known to the first great generation of U.S. astronauts, but with the advent of a new decade his qualifications and contributions to American rocketry may be somewhat obscured.

The *dramatis personae* of the astronautics effort of the People's Republic of China, including those who are interested in the specific problem of satellite tracking and in the problems of investigating and manufacturing exotic fuels, must include, in addition to Dr. Tsien, such persons, for example, as Pei Li-Sheng, Secretary of the Academia Sinica, Peking; Tung Chieh, Director of the Lanchow Branch of the Academia Sinica; Chao Chin-Chan, Director of the Institute of Meteorology, Peking; Lee Shan-Pang, of the Institute of Geophysics and Meteorology, Peking, and many others. It is also necessary to consider the writings of great scientific commentators such as those of Nieh Jung-Chen, including his "The Road of Development of Our Country's Scientific and Technical Work," published in *Hung-ch'i* [Red Flag], and his contribution, "Jen Min Jih Pao."

° ° °

The scientists of the Republic of China and those who have formed the Astronautical Society of the Republic of China are likewise making formidable contributions to all branches of astronautics, including applied mathematics, mechanics, thermodynamics, electronics, chemistry, etc. The program of static firings of rockets has now emerged into free flight-testing.

° ° °

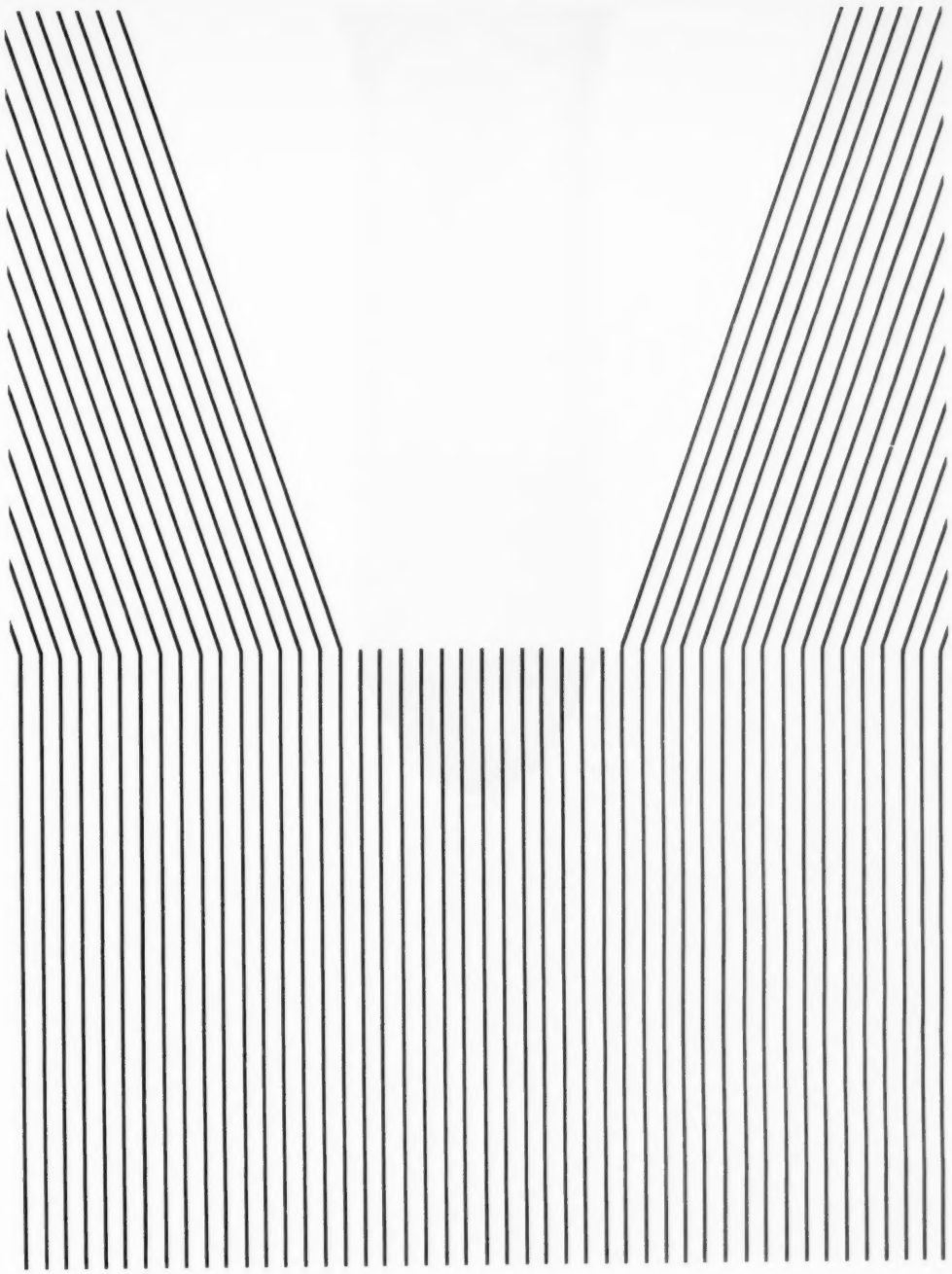
In the next issue, this column will further discuss the qualifications of the scientists of the Republic of China and the most interesting program emerging under the aegis of that country. In a subsequent article, the qualifications of the scientists working on the program of the People's Republic of China will be discussed, and the facilities and programs of this most important group will be outlined.

Japanese Rocket Society Plans Intl. Symposium May 24–28

The Japanese Rocket Society will hold a Second International Symposium on Rocketry and Astronautics at the University Club in Tokyo May 24–28, an announcement by Matao Sanuki, chairman of the symposium committee, notes. Deadline for 100-word abstracts of papers planned for presentation at the meeting is March 10; send to Prof. H. Itokawa, Institute of Industrial Science, Univ. of Tokyo, Chiba City, Japan.

BIS Planning Two Symposiums

The British Interplanetary Society is planning two symposiums of one- or two-day duration in June and July. One is expected to be devoted to space navigation, the other to instrumentation. Details on the meetings will be announced in the near future. ♦♦



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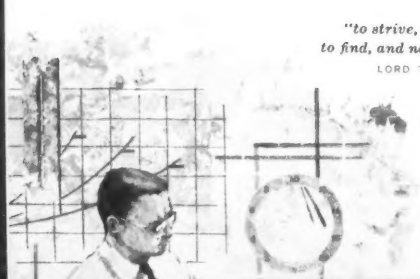

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COVER: *The glowing beauty of an experimental Rocketdyne ion engine operating in the laboratory suggests the promise of low-thrust space vehicles for interplanetary flight* (*see page 24*). (Full-cover ASTRO cover plaques, 11 x 12 in., are available from ARS Headquarters for $2.00 each.)

Astronautics

FEBRUARY 1960

Ardent Youth

The French have a proverb, "If the young only knew; if the old only could!" which might well be applied to a challenge now facing the AMERICAN ROCKET SOCIETY. The challenge lies in the proper inspiration and guidance of the many teenagers interested in space and rockets, and in the much unsupervised and sometimes catastrophic amateur experimentation which this interest has all too frequently produced.

The ARS Board and its Committees have listened to much evidence and deliberated at length on the need for a constructive youth program. One fact emerges clearly: Amateur testing with energetic chemicals is dangerous, and all the more so because the experimenter (and, unfortunately, often his adult "supervisor" as well) is too young or too inexperienced to know all the possible hazards.

The result of extensive Board and Committee study is a set of resolutions (page 30) which leave the ARS *firmly opposed to amateur rocket experimentation with hazardous materials, regardless of the supervision offered.* Moreover, the Society is by its charter legally prohibited from engaging in formal sponsorship of such hazardous testing.

At the moment, there is no alternative public position ARS can take. This is true in spite of what appear to be some carefully supervised amateur firings in the U.S. (including Hawaii), and in spite of the fact that we all recognize that a flat prohibition is never effective against strong human desires.

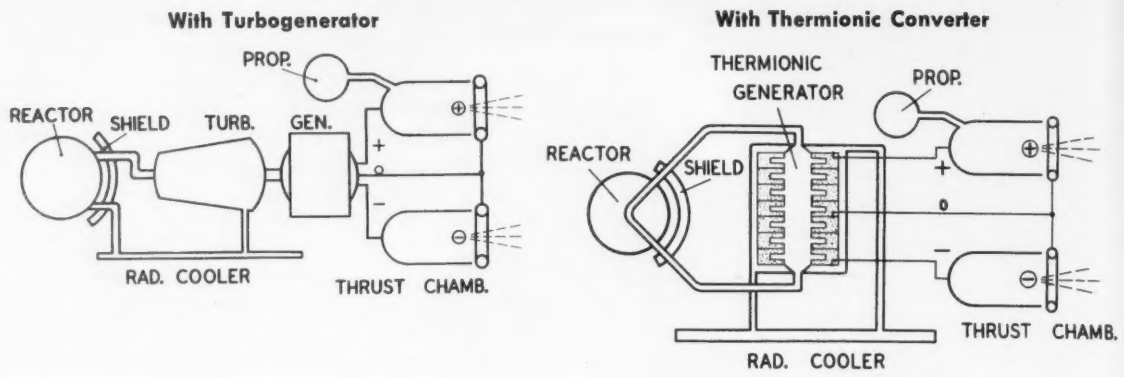
It is not necessarily true that ARS must maintain its firm opposition to all such experimentation indefinitely. It may be that a program can be arranged which will make it possible for certain amateurs to see their rockets loaded and fired *by professionals* on private and government ranges without hazard to themselves and without ARS legal involvement. There is, it must be admitted, skepticism that such a program *can* be developed. Amateur rockets are intrinsically unreliable; asking a professional to load and fire them does not alter that fact.

At any rate, the feasibility of such a program is being studied by the ARS Education Committee. Until a satisfactory program can be set up and approved by the Board, the present ARS position must stand. It will take time, perhaps a year or two.

Meanwhile, the opportunity for proper inspiration and guidance of eager youngsters must be grasped. There is so much fascinating yet nonhazardous physics, chemistry, and biology involved in astronautics and rocketry that it is not necessary to risk life and limb by conducting the wrong kind of experiments. The ARS Education Committee has been called upon to prepare a detailed program, including basic information and experiments, which will be available to schools, scout groups, and individuals who are trying to satisfy the youthfully insistent "need to know" and "need to try" which are among the nation's most valuable assets.

Liaison has already been set up with youth groups, educational institutions, industry, and government agencies. Many dedicated people are already working hard on the ARS Youth Program; many more will be needed. I can think of few more rewarding ways to apply our time and talents.

Howard S. Seifert
President, AMERICAN ROCKET SOCIETY



How useful are low-thrust space vehicles?

By the 1970's they will make possible large spaceships for manned expeditions to the moon and planets and unmanned probes with simple guidance for exploring the solar system's reaches

By Ernst Stuhlinger

ARMY BALLISTIC MISSILE AGENCY, HUNTSVILLE, ALA.

Ernst Stuhlinger, director of the Research Projects Laboratory of ABMA's Development Operations Div., received his doctorate in physics at the Univ. of Tuebingen, Germany, in 1936, and was assistant professor of physics at the Berlin Institute of Technology, doing research in nuclear physics, from 1936 to 1941. He joined the Peenemuende Rocket Development Center in 1943 and was active in the development of V-2 guidance and control systems. Coming to the U.S. under Army Ordnance Corps auspices in 1946, Dr. Stuhlinger did R&D work on missiles at Ft. Bliss and assisted in the V-2 firings at White Sands before joining ABMA in 1950.

ONE DAY in September 1906, it occurred to Robert H. Goddard that electrically charged particles, with which he experimented in his laboratory, might be useful for rocket propulsion, and he wrote a few words to this effect in his notebook. Some 23 years later, Hermann Oberth devoted a chapter of his book, "Wege zur Raumschiffahrt," to electric propulsion. Another 17 years later, J. Ackeret in Switzerland developed a general theory of propulsion which is applicable to electric rocket engines.

From then on, papers on electric propulsion became more frequent. Seifert, Mills, and Summerfield in our country described "jets of charged particles"; Shepherd and Cleaver in England coined the name "ion rocket" and described many of its characteristic features; Forbes, Lawden, and Spitzer developed essential parts of the theory of electric propulsion systems and calculated the trajectories of space vehicles powered by electric engines.

During the past 5 years, papers dealing with electric propulsion systems have numbered in the hundreds. Encouraging laboratory experiments have been carried out, and a number of government agencies proved their confidence in electric systems by supporting research and development work at many places.

The most fundamental distinction of an ion propulsion engine is high exhaust velocity with a low rate of mass flow. Electrically

charged particles can easily be accelerated to velocities of hundreds of kilometers per second with electric or magnetic fields, but the density of the flow will always be small because of the strong repelling forces the particles exert upon each other. In fact, the rate of mass flow is so low that electric propulsion systems provide only small thrust forces and consequently low vehicle accelerations of the order of only 10^{-4} g. Since this article deals specifically with low-thrust systems, we limit our considerations to ion engines.

It is obvious that the low thrust demands a long operating time if the system is to produce sizable terminal velocity. In fact, ion systems will be useful only when accelerations of the order of 10^{-4} g and propulsion times of the order of weeks to years are acceptable.

Such circumstances do exist, and under these circumstances the ion system promises great usefulness because of the very considerable payload it can transport. However, its application will remain limited to spaceflight outside any appreciable atmosphere.

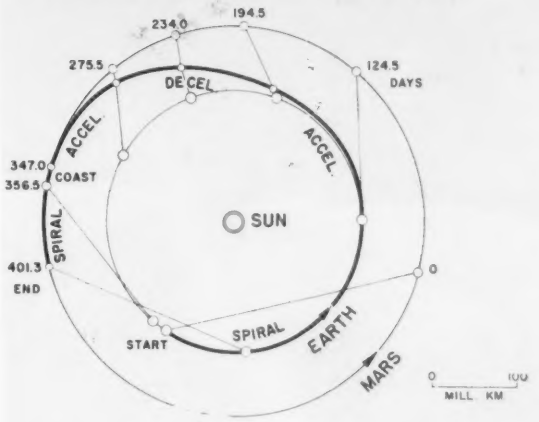
The Ion Propulsion System

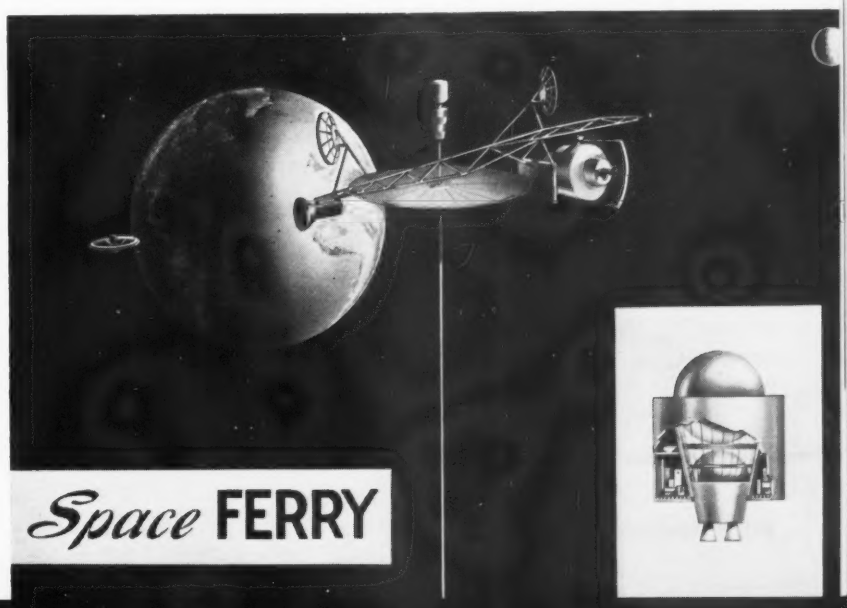
Before discussing the payload capabilities of ion vehicles, let us review the components of an ion propulsion system, and think of the mechanics of its operation. The sketches on the opposite page show the basic parts of an ion system—the nuclear power supply, the energy conversion plant that transforms heat into electric power, the ion source, and the electric thrust chambers.

The nuclear reactor will be of the fast fission type, with shadow shielding only. Heat is removed by a liquid metal coolant and transferred to the turbine working-fluid in a heat exchanger. Turbine and generator are housed in the same sealed capsule. The radiation cooler, shaped like a flat disk, rotates continuously to provide a force-field for the flow of the condensed working-fluid.

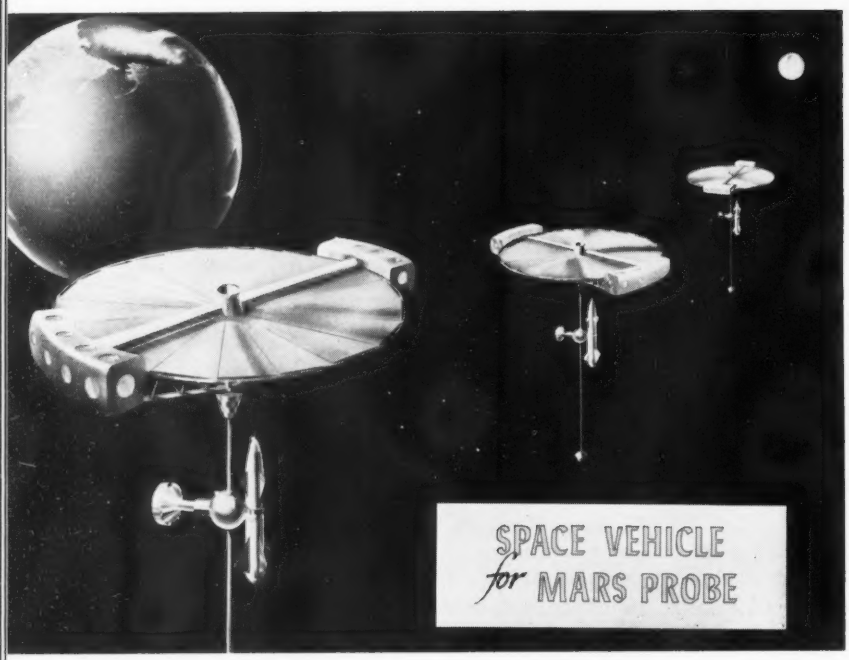
Based on present technologies, this power supply would provide an efficiency of 15 to 20 per cent for the conversion of heat to electric power. It is very possible that a different kind of conversion plant, the thermionic converter, will be of age by the time electric systems propel space vehicles. This device, at top right of page 24, consists of a hot electron-emitting cathode, a cooled anode at a close distance, and ionized cesium gas in the space between to reduce current-limiting space charge effects. Even though a refined working model of the thermionic converter has not been built yet, it appears possible that efficiencies of 30 to 40 per cent can be obtained.

Earth-Mars Transfer with Ion Propulsion





Artist's conception shows ion-propelled space ferry on the way to the moon. A 36-ton ferry could deliver a 100-ton payload in 52 days and return in another 8 days.



A fleet of ion-propelled space vehicles spirals away from Earth bound for Mars in this artist's rendering. Note rotating cabins on periphery of round reflector and piggyback landing vehicle.

A particularly intriguing design would contain a spheroidal reactor in the center and the thermionic cells on its surface. The outer shell, formed by the cold anodes, would radiate the waste heat directly into space. There would be no moving parts and no fluids.

The generator may be either an induction-type machine or an electrostatic generator running in the open vacuum. The latter might be considerably lighter.

The decisive figure of the power-producing plant is the electric power output divided by its mass, or "specific power." A conventional turbogenerator set may provide about 0.1 kw/kg. A compact, spheroidal, high-temperature thermionic unit might give about 0.6 or even more kw/kg. A specific power of 0.3 kw/kg has been assumed in the discussion which follows.

Performance Data for Ion-Propelled Space Vehicles

	Payload, tons	Total Mass, tons	Terminal Velocity, km sec^{-1}	Power, kw	Acceleration, g
Satellite Correction	4.9	5	0.4	5	5.4×10^{-6}
Transfer	50	72	6.0	4,600	2.3×10^{-4}
Lunar Ferry	100	136	10.5	5,700	1.5×10^{-4}
Mars Ship	150	435	72	28,000	1.1×10^{-4}
Jupiter Probe	1	5.5	90	450	1.4×10^{-4}
Deep Probe	1	16	160	2,000	1.2×10^{-4}

Nature of Ion Source

The ion source should be simple in design, light, efficient, and capable of a long operating time. The ions should have a large mass-to-charge ratio. It appears that a favorable choice would be the alkali element cesium, ionized upon contact with a hot surface of tungsten or rhenium. This ionization method, known for almost 50 years, works with an efficiency of over 99 per cent. It is simple and results in a relatively light and compact ion-source design. Current density, which determines the magnitude of the ion source, is limited by space-charge forces. Typical ion current densities are 5 to 15 milliamp/cm^2.

Space-charge forces also act within the ion beam after the ions have left the acceleration chamber. They must be neutralized to allow a flow of charged particles from the thrust chamber into space. Neutralization will be effected by mixing electrons into the ion beam as the beam leaves the thrust chamber.

In general, ion propulsion systems will be most advantageous when large payloads are desired for a given total weight and when low accelerations and long propulsion times are (CONTINUED ON PAGE 95)

Two permanent international space committees set up

UN General Assembly approves establishment of Committee for International Cooperation in the Peaceful Uses of Outer Space, while ICSU Bureau unanimously approves charter giving COSPAR permanent status

By Irwin Hersey

CLOSING out an eventful meeting, the UN General Assembly on December 12 established a permanent Committee for International Cooperation in the Peaceful Uses of Outer Space. The action followed by a few hours a UN Political Committee resolution calling for the setting up of such a committee.

Meanwhile, a few days earlier, Prof. H. C. van de Hulst, of the Netherlands, president of the Committee on Space Research (COSPAR), announced at The Hague that the eight members of the Bureau of the International Council of Scientific Unions (ICSU) had unanimously approved, by cable, a new charter for COSPAR, giving the group, which had been established by ICSU in October 1958 for a period of one year, permanent status.

General Assembly action followed an East-West compromise, calling for enlargement of the temporary committee, set up a year ago, from 18 to 24 members and increased membership for the Soviet bloc. The temporary committee had 12 Western members, three members of the Soviet bloc and three neutrals, and had been boycotted by the U.S.S.R. Two of the neutral members—India and the United Arab Republic—had also refused to participate because of the Soviet boycott.

The new 24-member committee is made up of 12 Western alliance members, seven members of the Soviet bloc and five neutrals. Members are Albania, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Czechoslovakia, France, Hungary, India, Iran, Italy, Japan, Lebanon, Mexico, Poland, Romania, Sweden, the U.S.S.R., the United Arab Republic, the United Kingdom, and the U.S.

The final vote in the General Assembly was 74 to 0, with the Dominican Republic abstaining and seven members absent. The committee's responsibilities, as stated in the Political Committee's resolution, are to:

"Revise, as appropriate, the area of international cooperation, and study practical and feasible means for giving effect to programs in the peaceful uses of outer space which could appropriately be undertaken under UN auspices, including . . . assistance for continuation on a permanent basis of the outer space research carried on within the framework of the IGY; organization of the mutual exchange and dissemination of information on outer space research; and encouragement of national research programs for the study of outer space, and rendering of all possible assistance . . . toward their realization," and to "study the nature of legal problems which may arise from exploration of outer space."

No Control or Regulation

Conspicuously missing from the proposal is any reference to control or regulation of military space projects, opposed by both the U.S. and U.S.S.R.

Another Political Committee proposal to the General Assembly called for an international conference this year or next for the purpose of exchanging "experience in the peaceful uses of outer space." Participation would be limited to UN members or members of its specialized agencies.

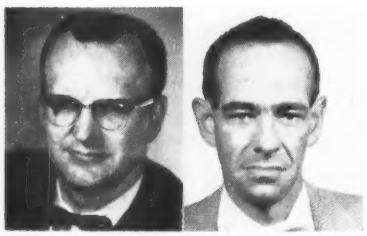
At the moment, the UN does not appear to have any plans for establishing a new agency to administer an international space program. Instead, the program is expected to operate through COSPAR, a nongovernmental group (CONTINUED ON PAGE 90)

Advantages of high-thrust space vehicles

High-thrust nuclear-propulsion vehicles compare well in performance with their low-thrust counterparts and offer important advantages from the standpoint of development for reliability

By M. W. Hunter and J. M. Tschirgi

DOUGLAS AIRCRAFT COMPANY, INC., SANTA MONICA, CALIF.



Hunter Tschirgi

Maxwell W. Hunter is assistant chief engineer for space systems at Douglas. He received an A.B. in physics and mathematics from Washington and Jefferson College in 1942 and an M.S. in aeronautical engineering from MIT in 1944. Joining Douglas that year, he served successively as a member of the aerodynamics performance group, leader of the missile aerodynamics group for eight years, and assistant chief project engineer for missiles. He was appointed to his present position in 1958. He also heads the ARS Missiles and Space Vehicles Committee.

Joseph M. Tschirgi is assistant chief for advance design of space systems, in charge of all advance design work on Douglas space systems. After receiving a B.S. in aeronautical engineering from Alabama Polytechnic Institute in 1948 and an M.S. in aerodynamics from the Univ. of Michigan in 1950, he joined Douglas and worked on Sparrow aerodynamics as well as on the preliminary design of several missiles, including Nike-Zeus. Serving in Douglas' Research Section since 1956, he was appointed section chief in 1958, in charge of all work on missiles and space systems, and in 1959 was appointed to his present position.

IT IS assumed by many people that really efficient space transports of the future will utilize electrical propulsion schemes, since they possess high specific impulse and allow very high payloads. This is felt to apply even if the weight of such systems is so high that the associated vehicles have extremely low accelerations and consequently long flight-times.

A comparison of certain advantages and disadvantages of both high- and low-thrust (acceleration) propulsion systems will be made here, particularly from the point of view of discussing certain advantages of high-thrust systems Relatively simplified analyses are used throughout, and the assumptions made are in general beneficial to the low-thrust devices. For instance, only missions that involve shuttling back and forth from orbit to orbit are considered, and the payload-comparison analysis assumes single-stage vehicles.

Systems with Nuclear Power Compared

All vehicles considered utilize nuclear reactors. Nuclear power is believed necessary for the electrical systems and could certainly be available for high-acceleration rockets in the same time scale. The term electrical rocket is used interchangeably with "low-thrust" (microthrust) and "low-acceleration" vehicle. What is really meant is low acceleration. If electrical rockets ever achieve power-conversion weights two orders of magnitude lower than assumed here, they will qualify as "high-thrust" (macrothrust) devices.

Any discussion of the advantages of a certain device involves a comparison. In making a comparison, one must be careful not to compare apples and oranges. To avoid such a trap, at least two criteria must be satisfied.

First, if the devices in question are not in existence, one should compare mechanisms which require nearly equivalent development time scales. In other words, it is unfair to compare electrical microthrust propulsion with currently available chemical macrothrust propulsion. Second, either comparison should be made on

the basis of devices possessing equivalent complexity or due allowance made for the differences.

The usually assumed electrical propulsion machine consists of a reactor-turbine-generator-accelerator assembly (see page 24) with a large radiator to allow a closed cycle between reactor and turbine, and is required to function for many months. This, to say the least, is a complex piece of machinery. Yet it is frequently compared to a conventional single-stage liquid-propellant rocket which must, to produce equivalent performance, function for only a matter of a few minutes.

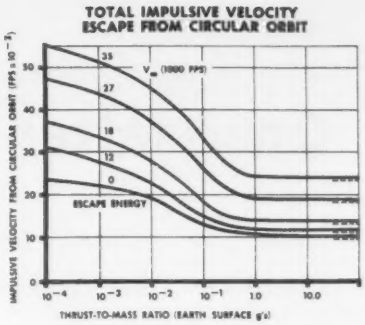
For the comparison here, assume the high-thrust vehicle to be a nuclear rocket utilizing hydrogen as a working fluid. This should require essentially the same development time as the reactor-turbine-generator electrical propulsion scheme. The high-thrust nuclear rocket operates only for minutes and is still simpler than the electrical machine.

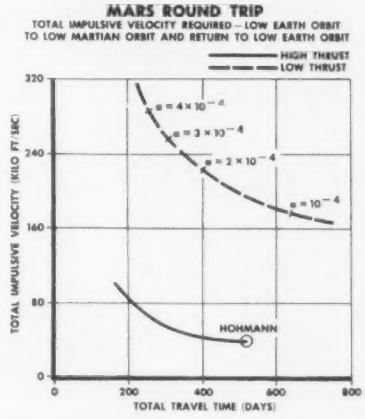
What Useful Loads?

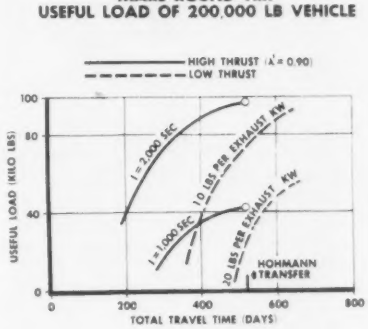
A comparison of vehicle useful load may be derived by first deducing the field-free (impulsive) velocity required to perform a mission and then relating it to the ratio of useful load to gross weight of the vehicles involved. In doing so, it is necessary that the penalty incurred by a low-acceleration device as it escapes slowly from a gravitational field be properly assessed. The magnitude of this effect is indicated in the first graph, where impulsive velocity to escape from an orbit is shown as a function of vehicle acceleration. Also shown are curves for given amounts of hyperbolic excess speed. This could be termed the kinematic inefficiency of microthrust. It is helpful to use this curve in defining high thrust. For the case of escape from circular orbit, appreciable kinematic inefficiency is involved only if thrust-to-weight ratios fall below the order of 0.5. Hence, in general, we think of high thrust as a thrust-to-weight ratio in excess of 0.5.

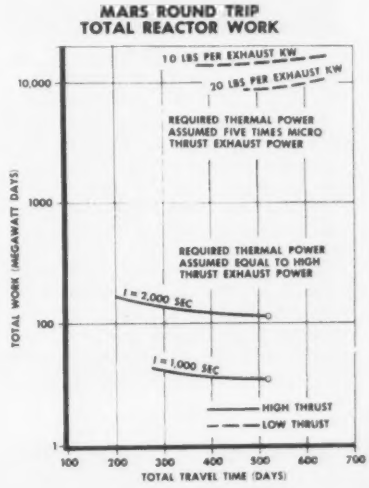
It would of course be possible to make a payload comparison between vehicles at constant total flight energy (hyperbolic excess velocity) directly from this graph, but in this case trip times would be grossly different. Acceleration time of the microthrust vehicle may even exceed the total travel time required by the high-thrust equivalent. For example, it requires nearly 200 days to accelerate to a hyperbolic excess of 35,000 fps at a thrust-to-weight ratio of 10^{-4}. However, for the same hyperbolic excess generated by a high-thrust vehicle, total travel time to Mars would be only on the order of 80 days. Of course, minimizing travel time in any transportation system has its own intrinsic value. In the case of manned space travel, time will usually be related directly to the required payload. From 6 to 15 lb/day are required to support a human, dependent upon the exact ecological system used. (A completely closed system is constant weight, of course.) Hence, in addition to the two criteria previously mentioned, a comparison between micro- and macrothrust on the basis of equivalent travel time is desirable.

Total impulsive velocities required of micro- and macrothrust vehicles to perform a round trip to Mars at favorable constellation times are plotted in the second graph. This presentation assumes departure from a low-altitude circular orbit about earth, transferring to a low-altitude circular (CONTINUED ON PAGE 99)




MARS ROUND TRIP
TOTAL IMPULSIVE VELOCITY REQUIRED – LOW EARTH ORBIT TO LOW MARTIAN ORBIT AND RETURN TO LOW EARTH ORBIT
HIGH THRUST
LOW THRUST
TOTAL IMPULSIVE VELOCITY (KILO FT/SEC)
HOHMANN
TOTAL TRAVEL TIME (DAYS)


MARS ROUND TRIP
USEFUL LOAD OF 200,000 LB VEHICLE
HIGH THRUST (η = 0.90)
LOW THRUST
USEFUL LOAD (KILO LBS)
I = 2,000 SEC
10 LBS PER EXHAUST KW
I = 1,000 SEC
20 LBS PER EXHAUST KW
HOHMANN 8 TRANSFER
TOTAL TRAVEL TIME (DAYS)

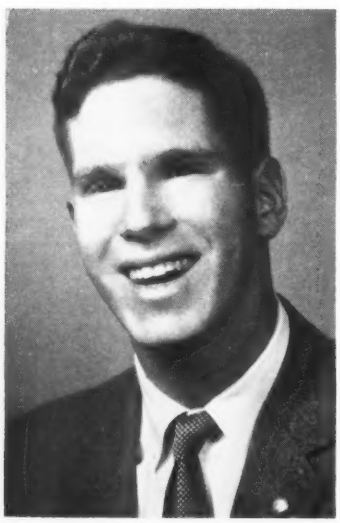

MARS ROUND TRIP
TOTAL REACTOR WORK
10 LBS PER EXHAUST KW
20 LBS PER EXHAUST KW
REQUIRED THERMAL POWER ASSUMED FIVE TIMES MICRO THRUST EXHAUST POWER
REQUIRED THERMAL POWER ASSUMED EQUAL TO HIGH THRUST EXHAUST POWER
I = 2,000 SEC
I = 1,000 SEC
HIGH THRUST
LOW THRUST
TOTAL WORK (MEGAWATT DAYS)
TOTAL TRAVEL TIME (DAYS)

Open letter to amateur rocketeers

Student of rocketry and astronautics, or Basement Bomber? The choice is still up to the amateur, and it can mean life or death

By Peter Zimmerman

STANFORD UNIV., PALO ALTO, CALIF.



Peter Zimmerman, a freshman majoring in physics at Stanford Univ., holds one of 100 General Motors National Scholarships awarded in 1959. He graduated from Highland High School in Albuquerque, N.M., where in his senior year he tied for first place in the New Mexico statewide physics competition. Active in amateur rocketry for many years, he served as president of two rocket societies; was also safety chairman of the Highland Rocket Society for two years; and was elected a student member of the ARS. He is a radio amateur and a former Eagle Scout.

MINUS 10 sec, 9, 8—the young scientist waits nervously behind a barricade—3, 2, 1, FIRE! From a steel tower many yards away the rocket roars upward splitting the sky with its wake of flame and smoke. An amateur rocket has once again made a successful flight.

Sure that's the way we would like it to be. But you and I know it doesn't happen like that very often. Let's roll back the film and see it the way it really is.

Minus 10 sec, 9, 8—the young rocketeer crouches nervously behind a rock 50 yd from the launching rack (a couple of boards nailed hastily together), his eyes peek over the rock to watch as the countdown finishes—3, 2, 1, FIRE! From the crude rack comes a head-splitting bang.

If the "young scientist" was lucky, the bang was several pounds of unpredictable propellant going off at just the right rate to hurl two or three pounds of tubing of uncertain composition into the clouds. If luckier still, a trail of smoke showed him which direction the missile went. And, if coincidence strained its arm, he, or some sane individual further back, actually saw the rocket in flight.

Your Career Can Be Short-Lived

Rockets and rocketmen are, however, notoriously unlucky! Probably that "bang" was the sound of a too thin or too weak piece of pipe being ripped into shrapnel by the pressure of too much propellant burning much too rapidly for the gases to get out through the faultily designed nozzle.

If luck had a change of heart, the guy back of the rock got out of it unhurt, but there was a good chance a piece of his bird came right back at him. If so, scratch two eyes and a career in astronautics.

Okay. You tell me it can't happen to you because you play it safe; you take precautions. That's what a couple of friends of mine said a week or two before "it" happened to them. Now one of them has only one eye and four fingers. They played it real "safe."

Look, what do you know about precautions? You're not trained chemists nor engineers, nor even explosives experts. You probably know not to smoke around propellants; you may know not to carry propellants in glass containers. But, do you know that to be safe you should use mixing spoons of aluminum or bronze to minimize spark hazards? Do you know to short your electrical firing lines till just before you fire? Do you even know how (CONTINUED ON PAGE 94)

Decision of the ARS General Counsel

(Dated Nov. 1, 1952, and reiterated at Board meeting Nov. 19, 1959.)

"The corporate powers of the AMERICAN ROCKET SOCIETY do not permit the Society to engage in experimentation. This is made clear when the present powers are compared with the powers contained in the original certificate. The amendment of 1947 specifically eliminated the power, originally contained in the certificate, to participate in experimentation in connection with interplanetary expeditions and travel. As a matter of law, however, even though rocket experimentation is not included in the corporate powers, the Society could be held liable for personal injuries and property damage resulting from such experiments carried on by a local Section if (it can) be shown that the individuals engaged in the experimentation were acting as servants or agents of the express or implied authority of the Society.

"The Society has adopted a policy forbidding experimentation by local Sections so that there will be no question of possible liability of the Society for injuries or damage arising from experimentation . . .

"The Society has advised interested members that they may conduct experimentation as a group, legally separate and distinct from the Society and the local Section. Thus, if individuals in local Sections desire to engage in experimentation, a separate legal entity should be formed by them for such purpose, and the entity must have no connection with the AMERICAN ROCKET SOCIETY. Even though the persons engaged in experimentation may be the same persons who constitute the local Section, the experimentation must be carried on completely separate and distinct from the activities of the local Section in connection with the AMERICAN ROCKET SOCIETY."

ARS Board Resolution on Amateur Rocketry

The Board of Directors, at its meeting on Nov. 19, 1959, in Washington, D.C., passed the following resolution in connection with the ARS Youth Program.

Resolved:

That the ARS embark on a positive program to encourage youth education in the sciences of rocketry and astronautics.

In the initial implementation of such a program, it is recommended that the Board, at this time, approve the following:

1. All elements of the program to be under the policy direction of the Board of Directors and its duly constituted committees, with staff support under the Executive Secretary of the Society.

2. The Board to call upon the Education Committee of the Society for the development of the program.

3. The Education Committee as a first step to prepare material for use by the Sections and by the individual members to fulfill the following objectives:

   a. Stress the importance of astronautics to the public, especially to youth.

   b. Stimulate interest in careers in astronautics.

   c. Inform youth and the public of the importance of the basic sciences and the dangers of amateur experimentation with hazardous materials.

4. The ARS efforts outside the Society to be based on the principle of encouraging interested and responsible youth organizations, such as Boy Scouts of America, Science Clubs of America, and similar organizations, to undertake, on their own, serious educational programs along safe lines.

5. Charge the Education Committee with the task of recommending additional positive steps to stimulate youth education in the sciences of rocketry and astronautics.

6. Charge the Executive Secretary with the task of distributing copies of this resolution together with copies of the written opinion of the General Counsel on the subject of experimentation to all Section officers, in the registered mail.

Background to the spacecrew holding facility

Work on the Discoverer biosatellite program that is leading to a facility for human astronauts prompted this special ARS roundup on the space holding facility

Ward Wells

By Major Julian E. Ward, USAF-MC

COMMANDER, 10TH TACTICAL HOSPITAL, SPANGDAHLEM, GERMANY, AND FORMER CHIEF, BIOCHEMICAL DIV., AF BALLISTIC MISSILE DIV.

and J. Gordon Wells

SUPERVISOR, HUMAN ENGINEERING, NORAIR DIV., NORTHROP CORP., HAWTHORNE, CALIF.

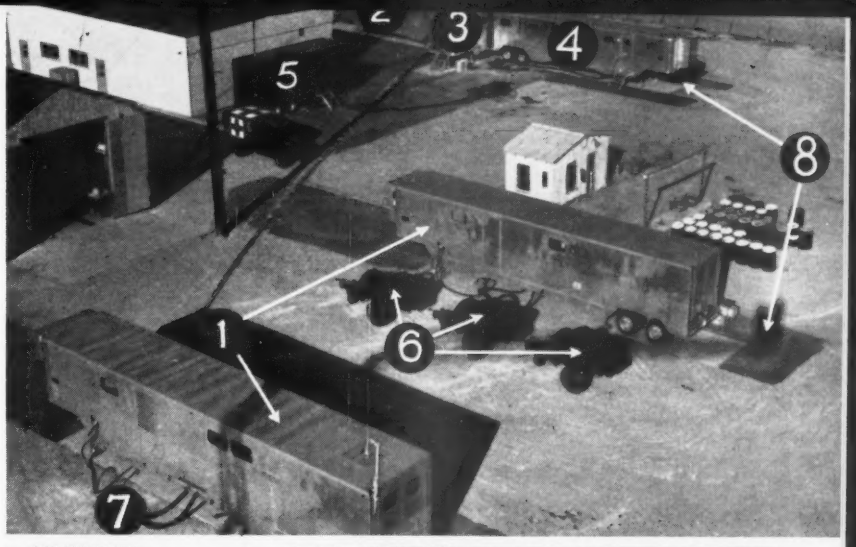
THE DEVELOPMENT of an organization and facility for the selection and prelaunch "holding" of spacecrews is not a totally new concept in aviation medicine. Until now, the somewhat more loosely associated offices of the flight surgeon, base hospital, BOQ, mess hall, officers club, and flying-safety officer fulfilled such functions for aircrews as those now being considered for spacecrews. However, intuition led us to believe, and more recently experience with animal satellite programs confirmed that, because of the nature of space missions and the unique preflight preparations of space vehicles, closer integration of the biological component with its vehicle was required from time of initial selection until actual flight.

The first design for a space holding facility to achieve fruition was that developed for the Discoverer biosatellite program. Six mobile and air-transportable trailer vans were designed and fabricated to provide ground support for all conceivable aspects of animal prelaunch activity. Two identical temperature- and humidity-controlled medical vans contain animal cages; training areas; complete surgery, X-ray, urinalysis and hematology laboratories; a kitchen for routine and special diet preparation; and living accommodations for full-time veterinary personnel. These vans incorporate the concepts of colony selection and isolation, maintenance of training efficiency, and preventive medical and surgical care. In addition, three vans (instrumentation, altitude chamber, and assembly) join to form a single complex providing facilities for complete prelaunch checkout and repair of the capsule environment control and other life-support systems. It is possible to closely simulate capsule absolute and differential pressures with the integral low-pressure chamber. This chamber is capable of achieving a 270,000-ft pressure altitude within 10 min. The design concepts utilized have been repeatedly prooftested to meet a requirement for continous surveillance of the biological specimen and environment during all phases of countdown. The requirement for a van providing a base-independent source of power has been repeatedly demonstrated.

Toward Man-in-Space Programs

From this stepping stone, improved concepts for other animal and, finally, manned space programs are being developed. The evolution of these concepts into "brick and mortar" stuctures is only a matter of months.

For this reason, the space holding facility was chosen as an appropriate theme for the Man-In-Space Session of the ARS Semi-Annual Meeting, held on June 9, 1959, in San Diego, Calif. Authors were requested to carefully consider the roles of the individuals required for staffing and functions and hardware required for implementing such a facility for the immediate tomorrow. This special *Astronautics* section on the space holding facility presents the rewarding results of the Session.



Shown at Vandenberg AFB, the biomedical van complex consists of (1) animal vans, (2) instrumentation van, (3) capsule-assembly and altitude-chamber van, (4) assembly and shop van, (5) auxiliary power van, (6) water trailers, (7) sewer connection, and (8) hardstands. Teardown time is 45 min, setup time about 4 hr. A field installation would not require sewer connections and hardstands.

Instrumentation van (near right) includes remote pCO_2 and pO_2 analysis devices, analog and digital recorders, memoscopes, multispeed photo recorders, etc. The surgery lab (far right) includes animal quarters that will handle four large chimps or dogs, diet kitchen and clinical lab, crew quarters, darkroom, and other facilities.

Altitude chamber, seen at rear, can simulate 125,000 ft in about 10 min and has a maximum simulation of 200,000 ft.

Itself providing technical planning and direction, BMD's Directorate of Bioastronautics, with the aid of the Aeromedical Field Lab at Holloman AFB, which did a design study for the van complex, and Consolidated Diesel Co. of Stamford, Conn., which produced equipment through a contract with Lockheed Missiles and Space Div., evolved the mobile biomedical van complex shown above. The van complex has now been shown to more than fulfill the following initial design objectives during numerous biomedical-package test programs and the preparations and countdowns for the Discoverer II and III biomedical packages:

1. Provide an animal-colony holding facility embodying the best principles of epidemiology and permitting detailed pre- and post-flight psychophysiological measurements and experimental preparations.

2. Provide for preparation, modification, repair, instrumentation, and countdown of sophisticated experimental bioastronautic packages.

3. Operate independently as a rugged mobile system able to support any bioastronautic project. ♦♦

The flight surgeon and the astronaut

Seeing manned spaceflight as a continuous and growing human discipline, rather than a singular and deviant technological feat, places the role of the astronaut's flight surgeon in the main tradition of aviation medicine

By Toby Freedman

NORTH AMERICAN AVIATION, INC., EL SEGUNDO, CALIF.

Toby Freedman, flight surgeon for North American Aviation, Inc., pioneered the aircraft industry's first full-time company program of aeromedicine for pilots. After receiving a Doctor of Medicine degree from Stanford Univ. in 1947, Dr. Freedman began his medical career with a three-year internship at Los Angeles County Hospital, where he specialized in internal medicine. Joining the Air Force Medical Corps in 1949, he graduated from the School of Aviation Medicine in January 1952, and served overseas in Japan, where he won the Bronze Star for meritorious service in 1953. Discharged with the rank of major in 1954, Dr. Freedman worked for two years as chief of the Allergy Dept. of the Southern California Permanente Medical Group, and then joined North American in 1956.

THE IDEAL senior medical officer at a spacecrew holding facility is a man of wide medical and aviation experience, stable, resourceful, responsible, and probably not subject to nightmares. But if he had one, I imagine it would go something like this:

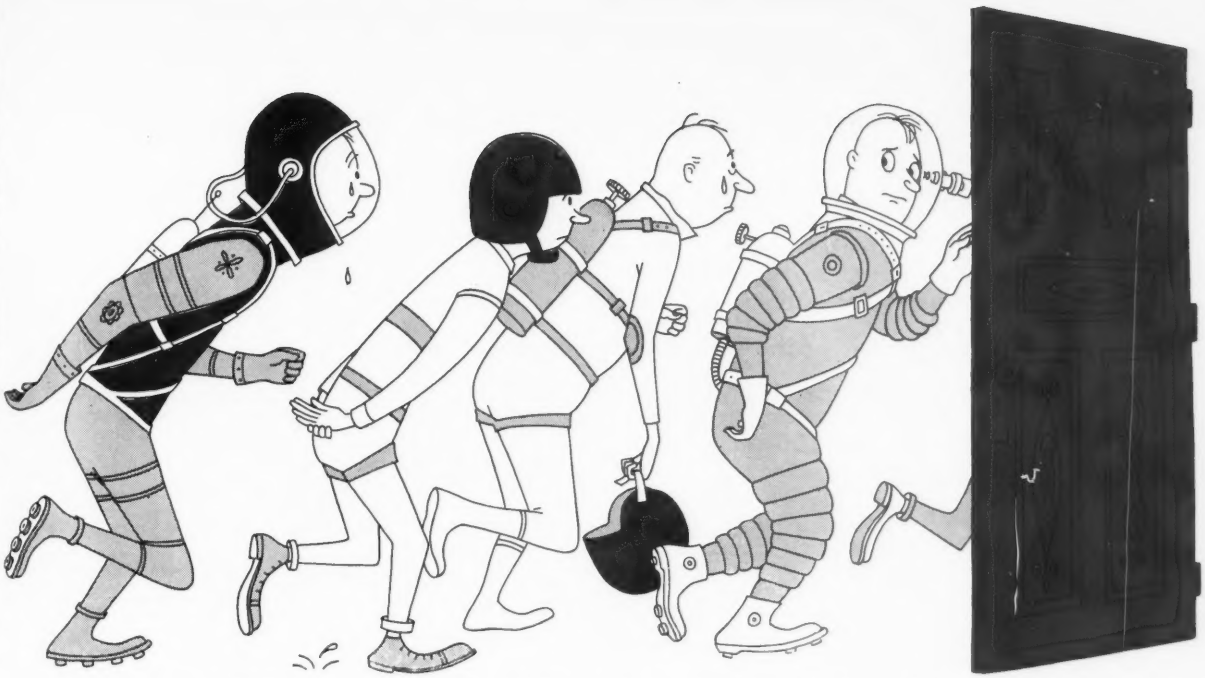
The medical evaluation board is in session, fingering their IBM cards and exchanging derogatory comments about the microclimate. Tomorrow is the launch and the space pilot has not yet been selected. "Joe's out," says the physical training instructor, "he can't run an 8-minute mile in his spacesuit." "You can't send Harry," says the astrophysicist, "his lunar landings are lousy." The psychiatrist and psychologist are both rubbing black eyes—it seems that Tom's passivity-aggressivity index just blew its epinephrine.

And so it goes. Dick's antibody titer is down, and Tom has developed an amniotic infatuation for the simulator. Herman alone is in perfect physical condition but, unfortunately, he's a monkey. What is the flight surgeon to do? Whom should he select?

At this moment the senior medical officer awoke from his nightmare. But he was still so upset trying to balance the reports of the epidemiologist, the psychiatrist, the aerothermodynamicist, and the medical electronicist—and come to some *decision*—that when his wife asked him if he wanted one or two drops of Sucaryl in his low-cholesterol Ovaltine, he broke down and cried like a baby.

In actual fact, the medical commander's responsibility requires the balancing and correlation of so many different specialized points of view—the assessment of factors as specific as blood pressure and as imponderable as motivation, the continuous modification and correction of planning in the light of developing information and research—that he is, in my opinion, in desparate need of certain broad general guiding principles.

One of these guiding principles, I would like to suggest, is that the



The senior medical officer at a spacecrew holding facility is prey to a recurring nightmare in which preflight examinations indicate that the only astronaut in perfect condition for the flight is Herman—and Herman, unfortunately, is a monkey.

holding facility and its activities are part of a long-range effort extending indefinitely into the future. The almost compelling tendency to regard the first spaceflight as the culmination should be overcome. Phrased more simply, the motto for the mission should not be "get a man into space" but "make manned spaceflight practicable."

Reduced to a sentence this is a truism. But applied to specific decision problems it is extraordinarily helpful. Once we adopt the point of view that spaceflight is not a single remarkable feat like climbing Mt. Everest but a long-range research and developmental effort, we find many possible difficult choices automatically settled for us.

I will try to illustrate the effect of this attitude in specific situations.

Quarantine Necessary?

Consider first the question of isolation from disease. Spacecrew candidates are very valuable men, selected and trained at fantastic expense. It is worth every effort to keep them free from disease, especially contagious disease, and we do have the technical ability to establish a quarantine of very high order. But is it wise to do this? Or should we, on the other hand, allow these men to live as normal a life as possible, compatible with their mission? Should they be isolated in a sterilized microclimate or be allowed to live with their chickenpoxed families? In short, should our astronaut sleep with his ultraviolet lamp or his wife?

There has been much debate on this subject, but our guiding principle settles it at once. If spaceflight were a one-shot affair, no precaution should be spared to keep the crew germ-free. Maximum isolation would be the answer. But once we realize that spaceflight is *not* a one-shot affair, that flight will follow flight into the indefinite future, and that the flyers will be these men, trained not for a single stab into the darkness but for continuing space exploration—then it is obvious that isolation is neither possible nor desirable. This is not an adventure of a few months, but a career. Naturally everything should be done to keep the holding facility sanitary and as free from disease vectors as possible. But subject to the limitations of his work and training, the space pilot should live a normal life.

Let us examine another question on which there has been sharp difference of opinion, provoking in fact the publication of the most fantastic and ludicrous proposals. This is the question whether the man in space should be in a certain strong sense an experimental animal or a pilot. We have read recommendations that the first man in space be a Buddhist, an Eskimo, a racing car driver, a Yogi, a mountaineer, a hypnotist, a jockey, or a psychotic underweight woman. Clearly all these suggestions have one thing in common. (CONTINUED ON PAGE 88)

Psychological problems of selection, holding, and care of astronauts

None of the many scientific and semiscientific treatises on spaceflight gives an adequate specification for the personality and regimen of an astronaut, but past experience has been combed to provide an approximation

By Siegfried J. Gerathewohl

U.S. ARMY MEDICAL R&D COMMAND, REDSTONE ARSENAL, ALA.

Siegfried J. Gerathewohl is chief of the Bioastronautics Research Office of the U.S. Army Medical R&D Command and staff adviser to the commander of ABMA. After receiving a Ph.D. in physiology, psychology, and human engineering from the Saxony State Univ. Institute of Technology in 1936, Dr. Gerathewohl was a member of the German Army Psychology Laboratory for two years and then joined the German Air Force, where he received basic training as a glider pilot and became chief of its Psychological Testing and Selection Center at Hamburg in 1940, and rose to the rank of major. He then held various positions in German industrial and aeronautical organizations in Germany until he came to the USAF School of Aviation Medicine in 1947 to work on crew selection tests, flight instruments, radar, etc. Later, while with the Department of Medicine, he engaged in pioneering experiments on weightlessness and space-cabin simulators. Before his present position, he was chief scientist for bioastronautics of AOMC. Dr.Gerathewohl holds the Arnold D. Tuttle Award for space medicine of 1958.

MAN has been designated as the weakest link of a space-vehicle system, and called a "noisy transmitter" and an "expensive nuisance" by many an engineer. Recently, the integrity of his objectives, as well as the sincerity of his motives for the exploration of space, have been seriously questioned. Very frequently we are asked, "What use is it to go into space?" There are many good answers to this question, some concerning objectives and others emphasizing individual motivation.

First, and most important in the concept of spaceflight, is the development of our technical capabilities and our determination to stay healthy and functional in the space environment. Until this objective is accomplished, all other considerations are of secondary importance. Let us not pretend that this is a highly scientific problem; it is predominantly an advanced engineering job. Having demonstrated that it can be done, we can proceed to research, experimentation, surveillance, and defense objectives in space. These objectives are predominantly practical and pragmatic, serving mainly technical, political, and national interests. Thus, the conquest of space also concerns some requirements of military support and strategy as important objectives, on which the reality and usefulness of space systems may be based.

Man's Motivation A Key

The second part of the problem concerns man's motivation, his cultural and sociological maturity, and his very strong drive toward inquiry into the unknown. Flying has always been closely related to taking risks and chances, to hazards and danger, bravery and courage. In selecting fighter pilots for the German Air Force in World War II, we always asked: "Why do you want to be a pilot?" In some cases, the answer was "because I want to fight and kill"; in others, "because I want to fly."

For this particular case, namely, the recruiting and selection of astronauts, the problem of motivation is of utmost importance. Several questions arise in this connection. For instance, is the flight-and-kill motive appropriate in view of our peaceful intentions in space? Are spacefliers supposed to be aggressive? Are the observa-

tions on the personality structure of military personnel engaged in unusual missions valid for the selection of spacefliers? Are the characteristics of the successful combat pilot desirable for the astronaut? Are deductions from previous selection procedures applicable?

In short, we cannot be sure that any of the criteria used before are adequate for the selection of astronauts, nor that validation scales hitherto employed can be successfully applied to our problem.

Crew Tasks Not Delimited

In none of the many scientific and semiscientific treatises on space travel has the task of the crew ever been specified in SOP terms. However, a few remarks about actual tasks and working conditions are already available, and some conclusions about job requirements can be drawn. The X-15 research program offers us a first glimpse into the structural and functional requirements of a modern boost-glide vehicle, while the Mercury project demonstrates the concept of the drogue re-entry capsule.

In both cases, quarters will be cramped and functional, instruments will be numerous and unique, but every effort will be made to relieve the pilot from the load. Once launched with relatively high acceleration, he will be automatically guided through his orbit most of the time. On the other hand, he will control his course, position, attitude, and velocity, and thus monitor his vehicle to a certain degree. Descent and landing, after an extended glide or high-drag acceleration, will require his skills and capability under extremely difficult circumstances.

Because it is impossible to test man's tolerance and ability in situations where he may be exposed to psychological and physiological stresses heretofore unknown, some of the anticipated conditions have been simulated in the laboratory. The first test battery used for actual screening of astronauts was constructed around such research findings and some more or less theoretical concepts. The program contained psychiatric and psychological testing, acceleration tolerance, somatotype information, cardiovascular-respiratory and physical fitness evaluation, temperature tolerance, isolation and confinement exposure, and noise and vibration tests. The results were correlated with other data available to produce an integrated psychophysiological evaluation of both the functional capacity and personality characteristics of the individual. At first look, the procedure appears very scientific and impressive. However, it also invites some criticism upon closer scrutiny.

In a recent presentation before the Aero Medical Assn. in Los Angeles, scientists involved in the selection of astronauts (CONTINUED ON PAGE 52)

The attributes, the present lives, the coming responses of the Project Mercury Astronauts, shown here attending a briefing on the Redstone booster at ABMA, form a focus for a study, once again, of mankind by man.

The role of simulators for spacecrew training

Simulators to train and check the capabilities of astronauts will form an important part of the space holding facility and require integral planning and design with the vehicle itself

By Gordon A. Eckstrand and Marty R. Rockway

AEROSPACE MEDICAL LABORATORY, WADC, WRIGHT-PATTERSON AFB, OHIO

Eckstrand Rockway

Gordon A. Eckstrand is chief of the training psychology branch of WADC's Aerospace Medical Laboratory. After receiving a B.S. degree from Northwestern Univ., he served in the Army during World War II and then returned to Northwestern and received M.A. and Ph.D. degrees in experimental psychology in 1947 and 1949, respectively. In 1949, he joined the Aerospace Medical Laboratory at Wright Field, serving successively as project scientist, chief of the training research section, and assistant chief of the psychology branch. Dr. Eckstrand became chief of the then newly formed training psychology branch in 1958.

Marty R. Rockway is chief of the training research section of the training psychology branch. During World War II, he served as a carrier-based naval aviator in the Pacific Theater. Immediately after receiving a Ph.D. in experimental psychology from Northwestern Univ. in 1953, Dr. Rockway joined the Aerospace Medical Laboratory, where he has since had extensive experience in the training-techniques research area, with particular emphasis on problems involving the dynamic simulation of complex man-machine systems.

OUR TOPIC is the role of the simulator in a spacecrew holding facility. Our emphasis, however, is on one particular class of simulators. We will not be concerned with simulation facilities developed to solve engineering design and evaluation problems but with—broadly speaking—training simulators designed to assist in the development, maintenance, and evaluation of human skills, knowledges, and abilities.

Let us first make certain necessary assumptions and stipulations. These so completely determine the nature of the discussion that it is important that they be made clear at the outset.

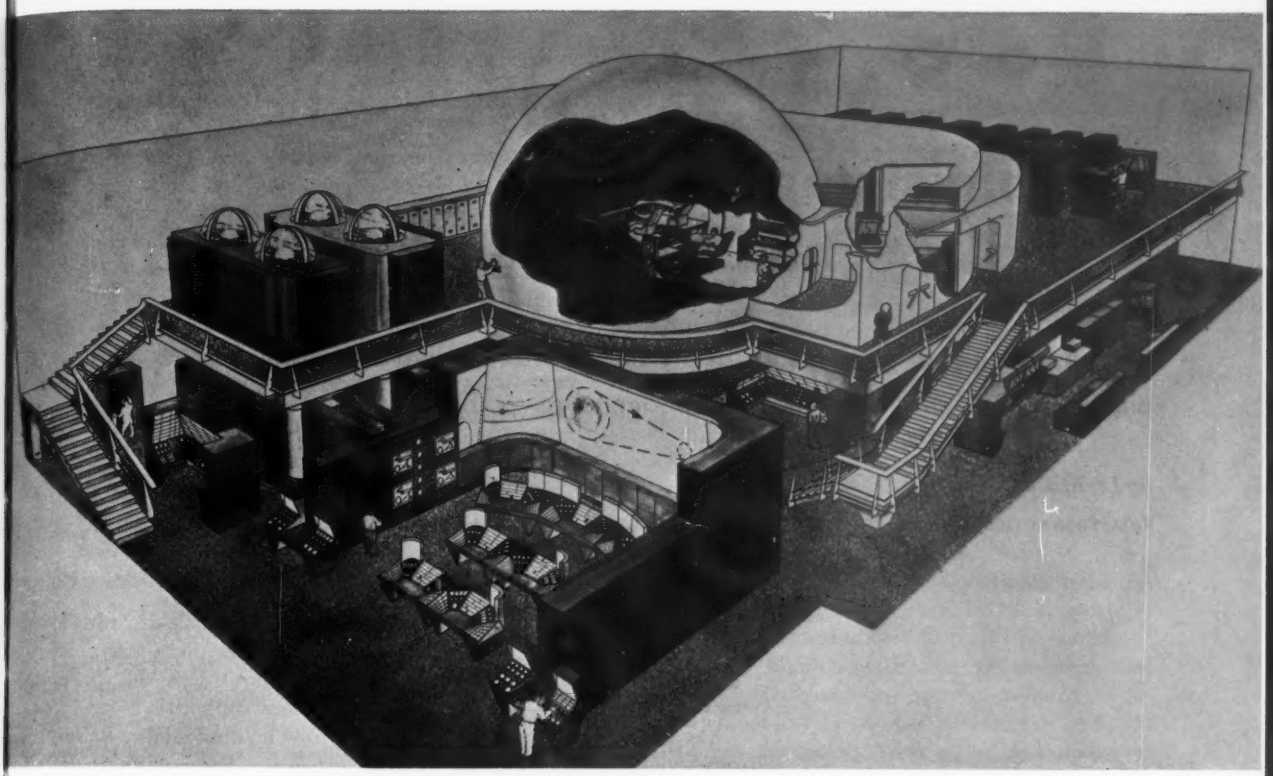
The first assumption concerns the functions that man will perform as a part of a space-vehicle system after launch. This may seem inappropriate in a session devoted to prelaunch activities. However, it is impossible to discuss the prelaunch role of simulators without first making certain assumptions about what man will do in space, since the human-performance requirements of the space-vehicle system directly determine the role that simulators can and must fulfill.

An Active Role for Man in Space

For purposes of this discussion, we will assume that man has a very active and important role in the space vehicle for which launch preparations are being made at the holding facility. This position, it seems to us, is defensible on the basis of the most recent planning and thinking to which we have had access. Man is being included in many current space-vehicle designs because of the added reliability and flexibility he makes possible. There are many missions which are simply not feasible without man at the present time.

But once having included man as a component through necessity, the designer frequently finds that over-all system effectiveness can be increased by assigning other functions to him either of a primary or a backup nature. Once you have paid the weight penalty required to carry, sustain, and protect man in space, it is important to utilize him as fully as possible.

With this introduction then, let us list some of the functions



This artist's sketch gives an impression of a training simulator setup for an advanced space holding facility.

which man might be expected to perform.

Malfunction Repair. Current calculations indicate that the reliability required for long-duration space missions cannot be attained with unmanned systems. As a result of this reliability problem, the detection, replacement, and repair of malfunctioning equipment offers one, if not the most important, role for the human. The role of space handyman may not be very glamorous, but it may well provide the reliability needed for the early exploration and exploitation of space.

Space-Vehicle Control. Considerable savings in weight and complexity of the navigation and control equipment can be made if man is included as a component in the guidance and control system. (This, too, can result in increased reliability.) Man is still the best adaptive-optimalizing servo presently known for complex tasks, and this is quite important in space missions where large changes in vehicle dynamics will occur in fairly short periods of time. Present data indicate that most, if not all, of the tasks envisioned for man are well within his capability.

Decision Functions. One such area, malfunction repair, has already been discussed. However, there are many other data organization and decision functions which man might also perform. Viewed in the general sense, flexibility—the ability to operate in unforeseen circumstances—is a very desirable feature for any space vehicle designed for military or exploratory missions. Yet it is almost a contradiction in terms to talk about preprograming equipment for the unforeseen. We can expect, therefore, that man will be assigned functions of just this sort—gathering and organizing data, making decisions about system states and mission status, and selecting appropriate courses of action permitted by the system.

Sensing. Man will undoubtedly also have certain responsibilities for sensing and taking action with respect to events outside the confines of the space capsule. This will be particularly true in the observation and selection of an appropriate landing site, whether this be an unexplored planet or the earth. With respect to complex stimuli, man's ability as a sensor, filter, comparator, and organizer are unsurpassed.

Monitoring Capsule Environments. Man cannot perform any function in a space-vehicle system unless his physiological integrity is assured Therefore, one of his functions will be to monitor and control to a limited extent the capsule environment. Although this does not contribute directly to system performance, it is absolutely basic, and must be considered in any discussion of spacecrew training requirements.

The second assumption that we must make concerns the definition and (CONTINUED ON PAGE 76)

The physiologist and the holding facility

The physiologist to the holding facility must have research background in physiology aviation and wide experience as a field training officer

By Lt. Bruce W. Pinc, USAF-MSC

BIOASTRONAUTICS DIRECTORATE, AF BALLISTIC MISSILE DIV., LOS ANGELES, CALIF.

JUST as the ground-support equipment of the ballistic missile differs significantly from that of the conventional aircraft, so must the support facility for the space-crewmen of the future, the spacecrew holding facility, differ from present aircrew support.

Let us look at the concept of the spacecrew holding facility before proceeding to the role of the physiologist in it. The facility as described and shown opposite is a prototype, and some of the requirements and functions outlined here for it may be modified or eliminated as manned spaceflight enters advanced-operation phases.

The objectives of this facility are to perform training and medical maintenance of the crewmen, establish the psychophysiological base lines, perform capsule assembly and checkout, and make a final selection of the space pilots from the crewman pool.

Bruce W. Pinc is biomedical project engineer for the Discoverer satellite program in the Bioastronautics Directorate of BMD. He received a B.S. in zoology from Northwestern Univ., an M.S. in physiology from the Univ. of Illinois, and did further graduate work at Illinois before entering the Air Force in 1954. After attending the School of Aviation Medicine and the Air Command and Staff School, Lt. Pinc served as a physiological training officer in the Strategic Air Command and as project engineer for partial pressure suits at the Aero-Medical Laboratory before coming to his present position.

Holding Facility Requirements

Such a facility has the general requirements of being geographically near the launch site, functionally independent, outside the range-firing hazard zone, and flexible in design. Functionally, it must provide spacecrew and support-personnel quarters, have a long operation capability, perform life-support-equipment modification, have a physical-conditioning facility, perform preventive medicine functions and crew-capsule integration and training, be capable of near-space simulation, and perform final screening and selection. To do these jobs, it must have the following components: Quarters, a simulator, training lab, shop, gym, and medical facility.

To man such a facility, three basic types of personnel will be required—operational, biomedical, and behavioral. Some of the staff should be in residence in the facility, i.e., medical and behavioral-science personnel. The purpose of "living in," in this concept, is to assure establishment of close rapport with the space-crewmen and to permit constant medical and psychological observation and support.

The operational personnel who do not "live in" include one medical administrator, two electronic engineers, two mechanical engineers, and two or more contractor technical representatives. The function of this group will be to provide program administrative

supervision, logistic support, capsule checkout, and sensor calibration.

Of the behavioral-sciences personnel, two do not "live in" while one psychologist does. This group supervises mission orientation and training, aids crewman-capsule integration, establishes psychological baselines, and performs control studies.

The biomedical personnel comprise the largest group. Of these, three are residents—the two flight surgeons (one of them a psychiatrist) and the physiologist. The mission of this group is the most extensive, including simulator operation, physical conditioning, preventive medicine, radiation studies, physiologic baselines, capsule checkout, and final selection of the crewman.

The role of the physiologist in the holding facility may be outlined as follows: He is in the biomedical section under the command of the senior medical officer (who is also probably the facility commander). Operationally, the physiologist performs the following six functions:

1. Officer in charge of the simulator facility and associated equipment, supervising the chamber technicians, directing maintenance and repair of the simulator facility and support equipment, establishing standard operating procedures for the simulator operation, and overseeing the simulator during man-occupied chamber operations.

2. Staff consultant on physiological problems which may arise during the course of the simulation, indoctrination, or integration programs. Further, he must be the expert source on applied physiology including the theory, function, maintenance, and repair of physiological sensors of the most advanced type. He must also be knowledgeable on instrumentation allied to physiological sensing and familiar with data presentation and reduction systems and telemetry techniques.

3. Staff consultant on personal equipment and life-support assemblies, with expert knowledge of pressure suits, helmets, and associated hardware and broad experience in the theory, design, function, fitting, maintenance, and modification of these devices. Further, he must be expert in the theory, mechanics, structure, function, modification, maintenance, and repair of the life-support assemblies within the capsule. The physiologist must have spent many hours in (CONTINUED ON PAGE 44)

Functional Requirements for the Spacecrew Holding Facility

1. Spacecrew and support personnel quarters
2. Prolonged operation capability
3. Life-support equipment modification
4. Crewman physical conditioning facility
5. Preventive medicine and health maintenance
6. Crew-capsule integration and training
7. Near-space simulation
8. Final psychiatric-physical screening and selection

FACILITY LAYOUT

Spacecrew epidemiology

Careful crew selection, isolation, and promotion of resistance to infection—all are vital to assure the success of space missions

By Col. Fratis L. Duff and Col. Thomas A. Collins, USAF-MC

GUNTER BRANCH, AF SCHOOL OF AVIATION MEDICINE, GUNTER AFB, ALA.

Duff Collins

Col. Fratis L. Duff, USAF-MC, was commander of the Gunter Branch of the School of Aviation Medicine at the time this paper was written, and is now deputy surgeon for USAF Headquarters in Europe. As much as five years before receiving his M.D. from the Univ. of Oklahoma in 1935, Col. Duff had been a reserve officer in the Army Quartermaster Corps, and in 1940 he entered the regular service, becoming engaged in research in pathology, virology, bacteriology, and parasitology, which he carried on in many tours of duty here and abroad. During assignment as professor of military science and tactics at Johns Hopkins Univ. between 1949 and 1951, he received a Doctor of Public Health degree. Certified in both public health and aviation medicine, Col. Duff was rated senior flight surgeon in 1956 and chief flight surgeon in 1959. He is a Fellow of AMA, ACP, ACPM, and the Royal Society of Tropical Medicine.

Col. Thomas A. Collins, USAF-MC, is director of the Clinical Medicine Div. of the Gunter Branch of the School of Aviation Medicine, where he teaches aviation and occupational medicine, the latter particularly as it relates to medical aspects of missile operation. In addition to A.B. and M.D. degrees from Stanford Univ., Col. Collins holds an M.A. degree in preventive medicine from Harvard Univ. and is certified in aviation medicine.

The authors note that their views as expressed here do not necessarily reflect those of the School of Aviation Medicine, the AF Medical Service, or the Air Force.

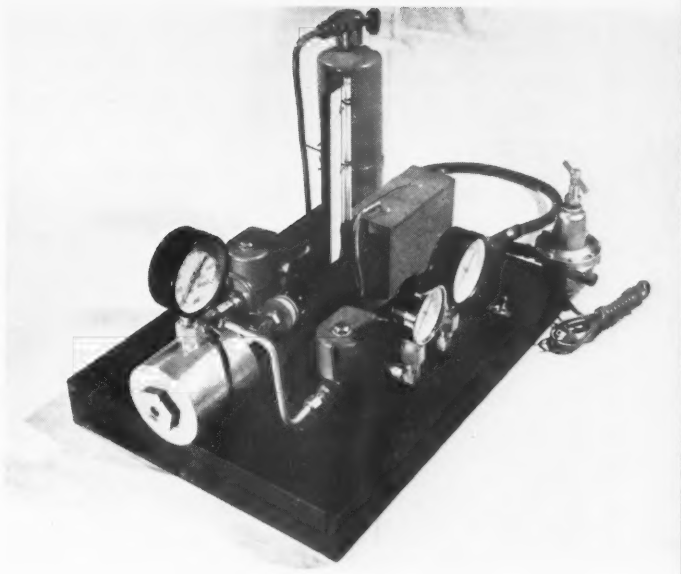
EVERYONE is well aware of the intricacy of the mechanism necessary to propel and guide a probe into space and of the numerous failures of such probes resulting from malfunction of one or more of their parts. In manned spaceflight, a second and even more complex mechanism will be joined to the system—the human being. This component is also susceptible to malfunction, and thus noneffectiveness, due to the effects of a variety of stressers. Successful launching and sustained flight into space therefore will require the proper functioning of both of these complicated mechanisms, and all applicable knowledge must be pooled toward that end.

Careful selection of spacecrews is essential to preclude physical and mental defects which could lead to mission failure, as discussed elsewhere in this special section of *Astronautics*. Measures designed to reduce or even eliminate the possibility of noneffectiveness occurring immediately before and after launch due to communicable disease processes are equally important, as years of careful and expensive research, development, and training could be negated by any one of a number of acute infectious processes developing in the crew in this period. Such preventive measures constitute the scope of this paper. The principles involved are tried and true, but could be overlooked in the many details of program planning. Certain valuable techniques to be mentioned, on the other hand, are as new and rapidly changing as spaceflight itself.

A Necessary Study

Epidemiological aspects of the selection of spacecrews and their alternates, as well as holding facility support personnel, warrant attention. Thoroughness and perseverance in obtaining reliable medical histories should reveal those susceptible to the common acute contagious diseases for which no reliable vaccines are available. Measles is a classic example. Unless overriding considerations necessitate calculated risks, such susceptibles should not be selected for holding facility duty. History of disease with a tendency to relapse under stressful conditions, such as recent malaria, should be cause for elimination.

Physical examinations should turn up those mild inapparent infections which under the adverse conditions of space travel could flare up, infect others, and bring (CONTINUED ON PAGE 44)



The Edroc, which burns propane and air at a combustion pressure of 80 psig, can be used to teach the fundamentals of rocket motors, as well as other scientific principles, such as Hooke's Law and electromagnetic induction.

Edroc—Educational rocket motor

This classroom demonstration unit and accompanying text offer teacher and student a basis for a beginning astronautics course

By Richard Hanbicki

ROTAUG CORP., NEWARK, N. J.

THE VERY serious problem of amateur rocketry in this country has never been more clearly delineated than in the recent ARS report on "Amateur Rocketry" (June 1959 *Astronautics*, page 34); also see pages 30–31 in this issue. As the report notes, not only is amateur rocket experimentation extremely dangerous, but, equally important, the great majority of such experiments contribute little or nothing to the knowledge of the experimenter.

Edroc Nominal Operating Specifications

Propellants	Propane/Air
Oxidizer flow rate	0.0025 lb/sec
Oxidizer chamber inlet pressure	110 psig
Fuel-flow rate	0.00017 lb/sec
Fuel chamber inlet pressure (at 70 F)	108 psig
Chamber pressure	80 psig
Optimum mixture ratio (O/F)	15.6
Thrust*	0.35 lb
Specific impulse*	130 lbf-sec/lbm
Exhaust velocity*	4180 fps
Combustion temperature*	4050 R

* At optimum mixture ratio.

While the zinc-sulphur-steel pipe approach may be dramatic, it is hardly the best, or safest, way to learn about rockets. The many tragic accidents which have occurred during the past two years in the course of such experiments offer ample evidence of this fact.

Consequently, in some schools, the study of rocketry is being discouraged because of lack of knowledge and the probability of accidents. Since many amateurs are sincerely interested in trying to learn the principles of rocketry, however, every effort should be made to guide them in a safe and effective manner. Normally, this would be the responsibility of their teachers, but teachers today are not generally in a position to furnish the necessary guidance. It therefore becomes the responsibility of the rocket industry to provide the teacher with an effective means of instruction.

One approach to the problem of safe rocket instruction in high schools and colleges is that developed by a team of rocket engineers and educators who have formed the Rotaug Corp. for the express purpose of achieving this aim. The Rotaug program covers three major groups—the average student, the advanced student, and the teacher. It should be remembered (CONTINUED ON PAGE 87)

professional opportunities at Honeywell Aero

APPLIED RESEARCH

This department must expand 100% in the next three years to explore many new areas and provide direction for the fast growing Aeronautical division. Opportunities for engineers and scientists exist in these areas of current investigation: computer systems, optics, inertial sensors, human factors, systems analysis, instrumentation and automatic controls. A few of the specific requirements are:

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ELECTRON DEVICE PHYSICIST: capable of independent research in molecular physics connected with generation of radiation and/or plasma devices.

PROGRAMMER ANALYST: mathematician with experience in the use of medium and large scale digital computers for analysis of scientific problems.

HUMAN FACTORS ENGINEER: capable of analysis and direction of experiments in human motor skills, and application to man-machine systems involving automatic control techniques.

If you desire to investigate any of the above professional opportunities at the Aeronautical Division, please write in confidence to Hugo Schuck, Director of Aero Research, Dept. 372

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Physiologist

(CONTINUED FROM PAGE 41)

chambers and aircraft actually wearing the equipment and depending upon the support assemblies for life.

4. Instructor in the indoctrination and integration program, presenting informal lectures to the crewmen and guiding discussion of the theoretical and practical physiology of spaceflight. These discussions should include a review of conventional aviation physiology, but concentrate principally on an engineering-oriented presentation of the physiology of fatigue, stress, nutrition, respiration, cardiovascular function, vision, disorientation, vertigo, acceleration, and the agravic state.

In addition to these more or less classical presentations, the physiologist must indoctrinate and integrate the crew members with the personal and life-support equipment. This instruction, will probably absorb the larger part of his time.

5. Evaluation-team member. This team, to which all members of the staff belong, evaluates the potential space-crewmen as they go through the training cycle with the objective of selecting at mission time the best candidate for the flight. The space-crewmen will probably be evaluated objectively with written tests and subjectively by personal observation. The physiologist should be an advisory member of the selection board, and the ultimate selection decision should be reserved to the medical and behavioral-science members of the staff. However, the physiologist's opinion will be indispensable in several respects. For example, the physiologist would be best able to evaluate the space-crewmen in the stress situation of the simulator.

6. Physiological-baselines consultant, assisting the medical officers in the establishment of physiological baselines. For example, vital capacity determinations, circulation times, BMR's, minute volumes, etc., which are not part of the preselection procedure, might be required by the medical officers as diagnostic or evaluative data. The physiologist can logically perform these tests, as well as assist in radiation studies and more common measurements.

A Professional Challenge

It is clear that the staff physiologist must be something more than the average physiological training officer. He must, of course, have wide experience as a field physiological training officer working with special flying personnel, but he must in addition be a research aviation physiologist. The physiologist selected, then, must have worked for at least 18 months in pure or applied research in aviation physiology. Preferably the work should have been in research and development of the personal and life-support equipment installed in the space vehicle. In addition, the physiologist must be unusually well versed in applied and classical physiology. Finally, since he plays a role in the selection and evaluation of candidates, he must be personable, capable of rapprochement, an astute observer, and an objective evaluator of behavior.

Obviously, such a man is not easy to find; but if the physiologist is to fulfill adequately the outlined functions, he must have in large degree these skills and virtues. ♦♦

Spacecrew Epidemiology

(CONTINUED FROM PAGE 42)

about crew impairment. Examples here are epidermophytosis, mycotic otitis externa, herpes simplex, and pinworm infestation. The presence of adent-tonsillar lymphoid tissue, although perhaps a protective barrier to invasive infection, serves as a repository of infective organisms to which other crew members may be susceptible, and thus is undesirable.

Clinical laboratory examinations in crew and support personnel selection should be intensive, utilizing the ultimate in current laboratory techniques. Both levels of immunity and detection of carrier states can be determined in laboratory centers with complete virology, parasitology, and bacteriology capability. Tissue culture techniques, for example, now permit determination of the carrier state of coxackie, echo and adeno viruses, the causes of certain respiratory, gastrointestinal and nervous system diseases which until recently were undetectable in the pre- and post-clinical states. Routine naso-pharyngeal, sputum, urine and stool culture, and inoculation studies may reveal the presence of potential pathogens harbored in apparently well individuals. Among these are micrococcus pyogenes, group A beta-hemolytic streptococcus, meningococcus, tubercle bacillus, and the entire group of common enteric pathogens—the Salmonella group, Entamoeba histolytica, and the enteric viruses. In the crowded confines of a space cabin, with agravic conditions, naso-pharyngeal droplets and fomites arising from

Kodak reports on:

film for photographing a tiny little speck in a great big sky...
what the big wheels do... a simple-minded stunt with a little honest fudging

"Shellburst"—ask for that by name

People who want to perform difficult feats by photography are always pushing us for something special in a film—something that is at once fast, fine-grained, high in contrast, high in sharpness—in a word, the paragon of all photographic virtue. Know what we recommend? *Kodak Linagraph Shellburst Film.*

Since (until now) we had spent less on advertising this film than we spend on lollipops for the kids at the annual office Christmas party, the product is little known outside of cinetheodolite and hydrogen bubble-chamber circles. The inquirer gets the satisfaction of having been tipped off on something special; and the antique, oddly militant name "Shellburst" sticks in the mind. Thus (and this makes strong admen blush) *Kodak Linagraph Shellburst Film* has turned into one of our most prosperous technical products. This is the black-and-white film for photographing a tiny little speck in a great big sky.

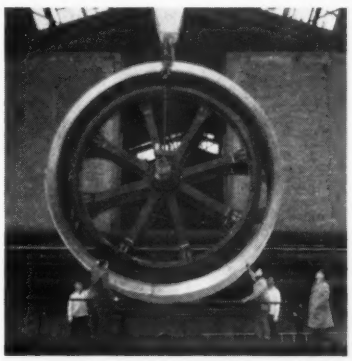
Now we wish to announce an upward shove in *Shellburst* performance. The spectral sensitivity peak has been shifted from 650mμ to 680mμ. This decision was reached at the cost of a vast number of man-hours, not only in the laboratory but out on deserts and hazy hillsides. In the course of these labors, good optical reasons turned up for peaking at 680mμ instead of pushing out to the infrared.

Along with the extension of red sensitivity, the new *Shellburst* has been endowed with 2) half again as much speed for the same graininess, 3) a significant improvement in acutance that is particularly prominent at high densities, and 4) a hardening of the emulsion to permit speedy hot processing.

With Gray Base it comes in 16mm and 35mm. "Gray Base" refers to an 0.22 density introduced into the support for antihalation purposes. With Clear Base it comes as 35mm and 70mm. This is usually preferred for use in instruments that record timing data, fiducial marks, etc. through the back of the film. For processing recommendations and the names of dealers who sell it, write Eastman Kodak Company, Photorecording Methods Division, Rochester 4, N. Y.

A kind word for triacetate tape

We make base for magnetic tape. Our base is cellulose triacetate, the same as in Kodak Aerographic Films for precision mapping from aloft. We cast it from solution on the nigh miraculously smooth peripheries of 18-foot wheels like this one. In the 330° of rotation



allotted for preliminary evaporation of the solvents before stripping off as sheet, the thickness—along with any thickness errors—shrinks by 4/5. Except for infrequent replating, these prodigious wheels have been rotating with stately unbroken angular momentum night and day, winter and summer, week ends and workdays for a full generation of mortal man.

Not only do our tape-making customers rival each other in excellence of deposition, but our cellulose triacetate has a rival of its own in polyethylene terephthalate, which is known as polyester. Because of the slightly higher price of polyester tape, it has often been assumed on all counts superior. This misconception hurts us.* The price difference at least partially stems from the higher salable yield that the tape manufacturer gets from cellulose triacetate. He has to reject less tape for deformation or "skew" and has the inherent thickness uniformity of the solvent-evaporation method to thank.

Though most of the tape being bought today is our beloved cellulose triacetate, there is a place for polyester. That we admit. It's very good for humidity amplitude and devilishly strong.

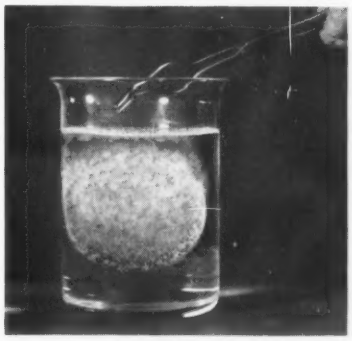
Cellulose triacetate, on the other hand, has only 15% ultimate residual elongation, not 45%. It does not go on stretching and stretching when overloaded by apparatus design that leans too heavily on strength of the tape base. In many applications a stretch of large and unknown magnitude could have a sneaky effect on the results.

*Another thing that disturbs us is inclusion of cellulose triacetate under the generic term "acetate." Fortunately, cellulose *di*acetate is fast disappearing from the tape market.

One other factor puts cellulose triacetate high with the man to whom the word "dropout" is an expression of horror. A dropout is caused by an inhomogeneity. Our cellulose triacetate, by the nature of its manufacture, is not likely to contribute inhomogeneity. Believe us.

Don't write to us about the foregoing unless you just happen to be in a mood for correspondence. All we ask is that you bear our assertions in mind when the occasion arises to specify magnetic recording tape.

A tough window for the infrared



Here represented is a nice piece of infrared technology. We take pride in it, even though they tell us it will never replace the foot-soldier.

Our simple-minded stunt photo demonstrates that a 3-inch flat of the new *Kodak Irtran Optics, Type AB-1* can be fused so securely into a stainless steel mounting that plunging it at 200°C into tap water generates steam but does no harm.

We have developed this *Irtran* material for transmitting in structurally adequate thickness more than 90% of impinging energy from 3 to 6μ. Not only does it withstand thermal shock, weathering, humidity, and abrasion, but, defeating the emissivity of "hot windows," it retains its high transmittance at 800°C and, possessing a refractive index less than 1.4, requires no coating to cut reflection losses.

The only fudging was a bit of detergent in the water. We justify this on the grounds that dividing the steam among a cloud of bubbles made the test more severe by increasing the cooling rate.

For the dope on what we can make in Kodak Irtran *lenses, domes, prisms, flats, and substrates for interference filters, write Eastman Kodak Company, Special Products Division, Rochester 4, N. Y.*

Kodak
TRADE MARK

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

body excretions will be heavily dispersed, and consequently they must be free of disease-producing agents.

A highly significant and promising development in the field of immunologis diagnosis is fluorescent microscopy. Through this technique, levels of immunity to all of the pathogenic organisms of particular concern might be determined, and retention or elimination will then be a matter of clinical judgment. One person found wanting in certain antibodies prevalent in those already selected could well be a cause for rejection. One note of caution enters here. In laboratory blood-sampling procedures, all syringes and needles must be used on a one-time basis to eliminate the possibility of infecting personnel with serum hepatitis or other similarly transmitted disease. Another important consideration for planning purposes is the time interval—up to six weeks—that the laboratory will require for these complete studies.

Once assembled for training and final preparation, the crew and support personnel ideally should be isolated from infecting agents. It is to be expected that in spite of careful clinical and laboratory examinations, the group will be exposed to one another's particular strains of pathogenic respiratory organisms, and a spate of "colds" can be expected until group immunity is established. The work of Paul and many others in immunological studies of isolated groups, such as the Spitsbergen Eskimos, clearly establishes the fact that all in time have specific common antibodies. Recent experience of extended undersea nuclear-submarine cruises, Antarctic exploratory operations, and adventures of small isolated groups such as that of the Kon-Tiki raft further substantiate this fact.

Problems of Location

To reach this healthy equilibrium, it is essential that care be taken in the location, design, and operational control of the holding facility. Minimum disease endemicity in the area is desirable. The establishment of a holding and launch facility in many geophysical areas will create problems of exotic disease control, because of high infection and carrier rates among the local population and widespread insect-vector and other transmission media. Security against potential insect vectors of disease, such as mosquitos, flies, ticks, mites, lice, and bugs is mandatory. Those responsible for both the design and the maintenance of the holding facility must provide for appropriate insectization—fine mesh screening, adequate lighting, avoidance of wall cracks and other hidden recesses, double doors at exterior entrances, and other measures as indicated by the local epidemiological situation.

Security against contact with potential human carriers of disease or fomites emanating from outside the holding facility, either accidental or subversively intended, should be the maximum consistent with essential operational considerations. Illustrative of the disease potential in this regard is the reported instance of a presumably healthy seaman being taken aboard a Navy submarine at sea by transfer during an extended cruise, with the subsequent outbreak of acute respiratory disease throughout the crew. Again, it has been reported that on one of Shackleton's Arctic explorations bales of clothing packed in London were broken open and the entire party, previously free of infection, promptly developed respiratory disease. Air cleaning of the entire holding facility is desirable, with electrostatic precipitation of airborne particles being the method of choice. Surface cleaning should be by suction, electrostatic, or viscous attraction methods. Finally, adequate inspection and laboratory examination of food and water supplies is necessary, both before and following delivery to the facility, to preclude contamination.

Time for Immunities

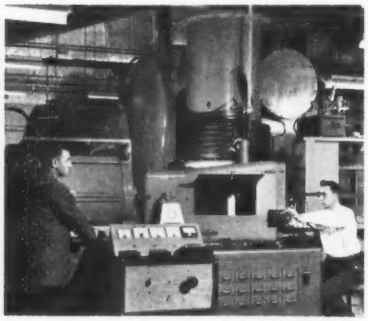
The importance of acquired group immunity by intimate closed population contact has already been mentioned. The training and holding period must be sufficiently long to allow clinical manifestations of the prevalent diseases to present themselves among susceptibles. A minimum of four to five weeks is recommended for this purpose.

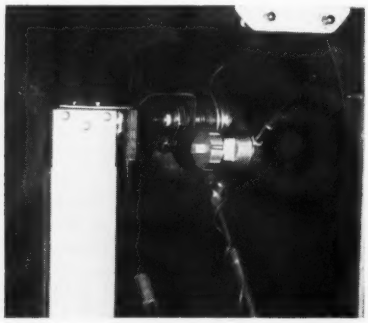
Active immunity by artificial means should be established among the crew and support personnel prior to congregation. All routine initial or booster immunizations for the particular launch area should be accomplished, including of course poliomyelitis vaccine and polyvalent influenza vaccine composed of strains existing or ex-

Solar-Powered Thermionic Converter

The TRW Tapco Group's New Devices Laboratories has announced the successful development of the pictured solar-powered thermionic converter, which is the possible basis for a Helionic (Tapco trademark) power system for space applications.

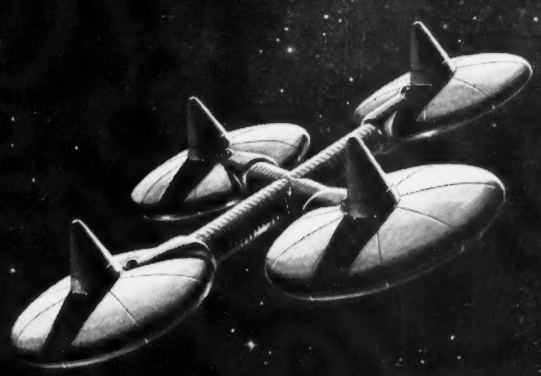
Recent tests with the device lead Tapco engineers to believe that it will give power densities of 20 to 30 watts per cm^2 of emitter area. Theoretical analysis indicates that a conversion efficiency of 43 per cent is possible for a device with optimum design and a current density of 20 amp per cm^2. Specific powers of 18.5 watts per sq ft of solar concentrator area are predicted for Helionic power systems utilizing this converter.

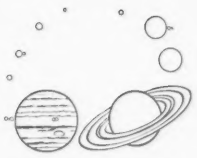




Left, engineers at the Tapco Group's New Devices Laboratories operate an arc-imaging furnace as a solar simulator for research in thermionic power conversion systems. The furnace provides a noncontaminated heat source for 6700-F temperature at the focal point of the imaging mirror by concentrating radiation from the carbon-electrode arc through precision-finished elliptical reflectors. Right, a thermionic diode mounted in the solar simulator. The vertical column on the left positions the mechanism for proper alignment of the diode in the focal point of the mirror. The anode lead is shown coiled around the cesium injection tube.

Douglas engineers spin new cocoons for tomorrow's space travelers





Space researchers in human factors engineering utilize latest discoveries of medical science

Each time a space traveler leaves home (earth) he has to be completely wrapped in a special environment. He needs it to survive under alien conditions such as extreme heat and cold, high vacuum, cosmic radiation and tremendous G forces.

At Douglas, life scientist research over the past ten years has explored more than *forty* basic factors relating to human survival in space. Douglas engineers are now completing – at military request – a careful survey of conditions that will be encountered en route to and on other planets. They are also evolving plans for practical space ships, space stations and moon stations in which men can live and work with security thousands of miles from their home planet.

Out of these research activities and those made by companion workers in this field has come new knowledge of great medical importance . . . even to those of us who are earthbound.

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pected in the particular year and geographical area. The flight surgeon in charge should be aware of and should administer any new special vaccines which have been clinically tested and found to be safe and effective, such as Type 3, 4, 7 adenovirus vaccine. Again, one-time use of syringes and needles is mandatory.

The use of agents to produce passive states of immunity must be guarded to avoid delayed sensitivity reactions to sera. The chance of reaction or inadvertent infection in the administration of globulin blood fractions is remote, but nevertheless real. However, the presence of infectious hepatitis in the area may warrant the use of gammaglobulin as a protective agent against this disease, particularly in the event of a flight profile of short duration, inasmuch as there is presently no way to determine immunity to viral hepatitis, and no way to vaccinate against it. Of interest is current research in further fractionation of the globulins, which promises to provide more specific passive protection against various disease agents.

Consideration could also be given to the prelaunch administration of suppressive and prophylactic drugs, if suspicion exists that disease agents, susceptible to the drugs, may have been introduced. Again, clinical judgment is necessary to weigh this risk against the risk of inducing drug reaction and lowered stress tolerance productive of noneffectiveness after launch.

Measures to promote nonspecific resistance to infection should be taken, although of relatively little proven importance. Microclimatic control in the facility within the so-called comfort zone is worthwhile. No irrefutable proof is available that sudden chilling or overheating can be implicated in the production of respiratory infection. Nevertheless, it is reasonable to avoid such, particularly sudden temperature, humidity, and air-movement changes on entering or emerging from long training periods in the space-cabin simulator. Again, from the standpoint of susceptibility to infection, fatigue and improper nutrition cannot be unequivocally indicative, but other considerations warrant careful attention to these health and morale measures during the prelaunch phase.

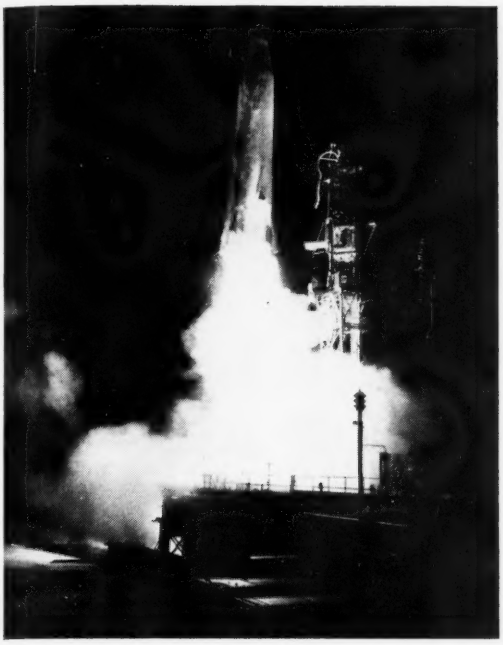
Unnecessary epidemiologic hazards should be excluded from the holding facility design. In our opinion, the undesirable aspects of swimming facilities outweigh the exercise and morale advantages. Among the former are the ease of contamination of swimming pool water with disease agents, particularly viral, which in many cases are highly resistant to chlorine; the washing away of protective barriers to infection in the nasal passages; and the admission of optimal conditions for fungal and bacterial dermatitis. Exercise could be accomplished more safely in a sanitary and well-supervised gymnasium program.

Noninfectious Dangers

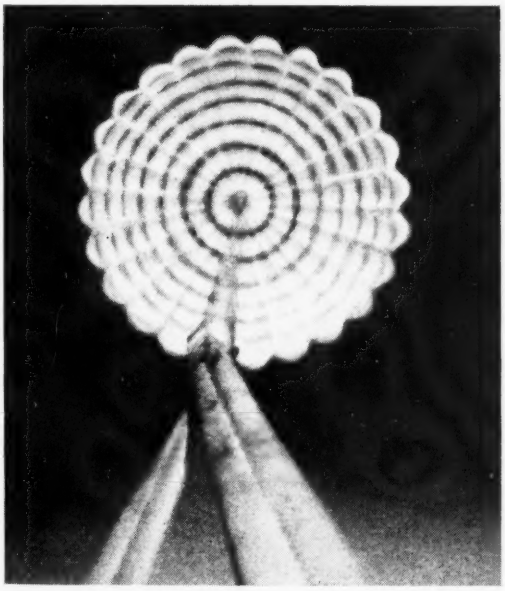
In passing, noninfectious but nevertheless communicable conditions detrimental to mental and physical health should be closely watched for in the training period, particularly during prolonged stays in the confined space of the simulator. Excessive body odors and gaseous emanations on the part of certain crew members may warrant their rejection to avoid performance degradation of the others from irritability, anorexia, and even nausea. Irritating habits and overbearing personality traits must be observed and evaluated, as their effects could easily be a communicable liability to the entire crew. Group dynamics as a psychological consideration in spacecrew selection and training is being separately studied and extensively reported, but in a sense is part and parcel of the over-all epidemiological approach.

As in all complex human endeavor, compromise in insuring crew effectiveness in regard to communicable disease may be necessary. Complete isolation may not be practical, and overriding operational and morale requirements may break this isolation at any prelaunch phase. Similarly, there exist no protective immunizing procedures against many diseases. When such does exist, it is still only relative, subject to failure by overwhelming doses of infecting agents, except perhaps in the case of vaccination with living viral antigens. Certainly every effort should be directed toward isolation by prestocking of supplies to reduce contact with resupply agencies to a minimum during the holding period, by using electrical means for outside communication when possible, and by eliminating unessential contacts. Initial medical selection and rejection procedures, and further elimination during the holding period should be as rigid as the otherwise qualified manpower pool permits, with little or no allowable compromise on adequacy of facility design and maintenance from a preventive medical standpoint.

Thus, no one of the three major priniciples—selection, isolation, or promotion of resistance—can be relied upon alone, but rather a combination of them is necessary to assure mission success from an epidemiological standpoint. ♦♦



THE ATLAS MISSILE LAUNCHED NASA'S one-ton instrumented capsule similar to the one that will carry a man into space orbit. Initial landing phase began at 45,000 feet when a barometric switch fired a charge which deployed a Radioplane stabilization parachute directly aft into the airstream. At the same time, radar chaff was ejected to scatter into a 600-square-foot pattern to provide for radar locating and tracking.



AT 10,000 FEET another barometric switch initiated release of the stabilization 'chute and deployment of the 63-foot Radioplane Ringsail landing 'chute to safely lower "Big Joe" in its 30-feet-per-second descent. Upon water contact, a pyrotechnic charge released the Ringsail. Recovery was completed when a U.S. Navy destroyer, guided to the capsule by radar, lifted the undamaged "Big Joe" space capsule from the Atlantic.

NEWS IS HAPPENING AT NORTHROP

AFTER SPACE FLIGHT RADIOPLANE'S RINGSAIL BRINGS "BIG JOE"–NASA'S ONE-TON CAPSULE–TO SAFE LANDING

Recently the Space Task Group of the National Aeronautics and Space Administration sent its "Big Joe" capsule into space and successfully recovered it hundreds of miles down-range from Cape Canaveral. The landing system included a 6-foot conical ribbon stabilization parachute and a 63-foot landing parachute, the Ringsail. Both 'chutes, supplied by Radioplane, are proof of new advances in paradynamics.

Radioplane, also chosen by McDonnell Aircraft Corporation to develop and supply the landing system for NASA's Project Mercury, salutes its associates on this achievement. The success of this demonstration shows the ability to bring a man home safely after orbital flight.

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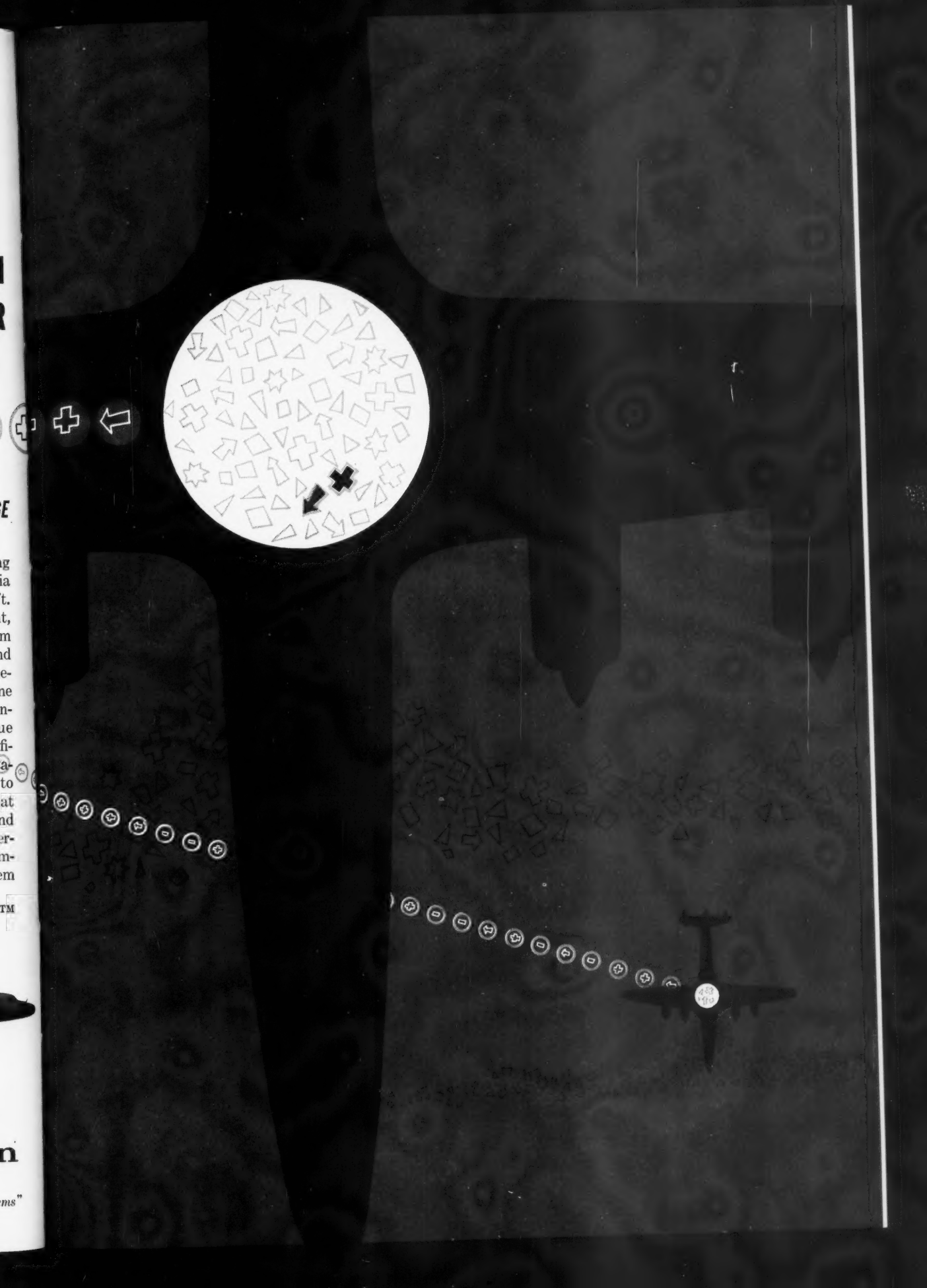


Psychological Problems

(CONTINUED FROM PAGE 37)

summarized the results of their work as follows: "The performance of these candidates was impressive. While not supermen, they are intelligent, mature, deliberate, and confident individuals. On the whole, they are unusually well-functioning, highly endowed people, who will be able to deal effectively with the complexities of manned spaceflight."

While this statement may prove correct, it very easily lends itself to false interpretation. The fact is that all these individuals belong to an extremely selected, trained, and restricted population. Since all were graduates of test-pilot schools and were competent aviators and engineers, their ability was reestablished through the same criteria which were essential for each individual's professional success. Further extrapolations into space activities are purely speculative, since neither validation and correlation figures with actual space missions, nor data on group experience and cumulative and order effects of the anticipated stresses, are available as yet.

The Long Hand of Freud

Of particular interest is the objective of psychiatric and psychological testing, namely, to develop an understanding of the subject's personality, particularly in reference to his handling of physically and emotionally stressful situations, through use of psychiatric interviews and personality tests. These interviews were unstructured. However, in general, primary interest was paid to background information, family history, identification, infancy, childhood, school, and social, occupational, sexual, medical, military, and accident history. Other areas explored were fears and phobias, attitudes toward time, sensations of isolation, and motivations involved. The individual's perceptual, intellectual, emotional, and action functions and his relationship to his task, himself, other people, the present, and the future were assessed, and an attempt made to describe his personality type, energy level, ego strength, characteristic mechanisms, and other psychiatric attributes.

This approach, nonobjective or subjective as it may be, is as unusual in U.S. aircrew selection procedures as the objective of the mission. Actually, this part of the screening technique is very similar to Murray's system of personality assessment and Simoneit's characterologic method, used by McKinnon for selecting applicants for O.S.S. in WW II.

In such a system, the abilities and skills of the individual are evaluated on the background of the whole personality by imagining how this particular individual will utilize his capabilities under anticipated conditions, and how the structure and stability of his personality will maintain integrated behavior for survival and success. Since we had remarkable results with a similar test battery in Germany, I advocated this method for the assessment of personnel exposed to unusual missions, and I think it is very fortunate that it is now being tried in such an outstanding program in this country.

As to the Astronauts already selected, the procedure seems to have paid off so far. They are thoroughly prepared through their experience in testing and research to cope with unusual and dangerous situations, and they are eager to go. They accept their assignment as a natural extension of their job. Of course, simulation of space missions and further training is absolutely necessary.

For unusual missions of this sort, the principle of "voluntaryism" has been generally accepted at face value. Actually, this is not necessarily so. Scott Crossfield recently told me that nobody asked him whether he wanted to fly the X-15, and that he had been handed the job. Apparently, North American took it for granted that he was going to do it. On the other hand, public or social pressure can make a man volunteer against his own desire, as can national interest, religious conviction, or moral considerations.

If the stakes are high and promise exceptional gratifying rewards, man will subject himself to extraordinary demands. There are still some open questions concerning voluntary versus nonvoluntary assignment and the ability to survive. I don't think it makes too much difference. The important thing is to furnish the man all the tools for continuing the fight. As long as there is a fighting chance, volunteer and nonvolunteer most probably will act alike.

One last remark in this context concerns the identification of the "normal" and the "outstanding" personality and its tolerance to stress. In its March/April 1958 *News Report*, the National Academy of Sciences–National Research Council published an abstract on "Medical Follow-up Studies on Veterans," in which the investigators made a systematic analysis of the chance of breakdown in relation to predisposition and military stress. The analysis, involving 1500 Army and Navy veterans, revealed that only a few of the men who broke down could be regarded as screening errors. Conversely, psychiatric screening could not be relied upon to prevent much of the emotional burden of war. "Furthermore," the report states, "many men with apparent predisposition to breakdown served long and well, including tours of combat. It would be hard to say that the men with psychoneurosis as a group in any sense failed to be of value to the services." There is even some evidence that some abnormal personalities, showing fanatic or obsessive-compulsive behavior, for instance, may be able to tolerate higher stress than the normal man.

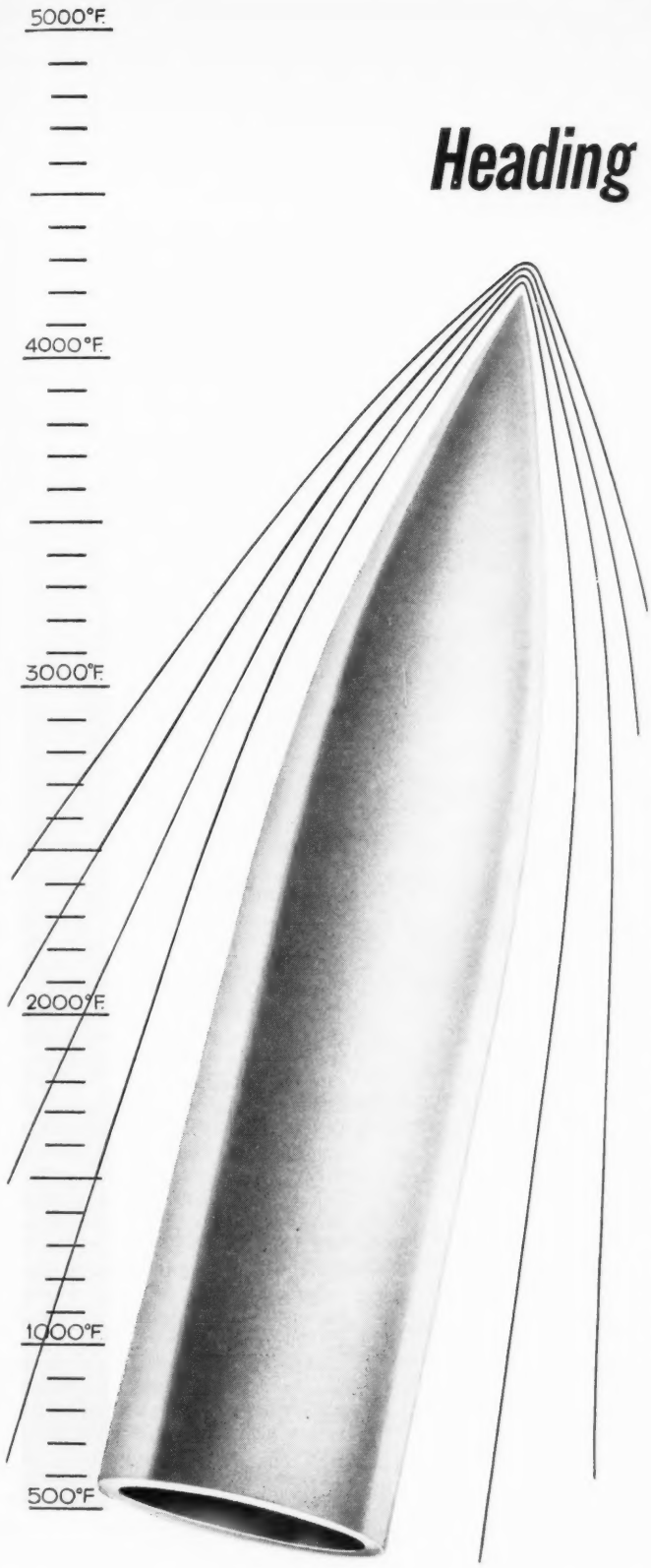
It is the intimate knowledge and understanding of human nature and its reaction to stress that may lead to the essential criteria of success in spaceflight. Unless the background of these psychodynamic processes has been explored, no final formula for the prediction of human behavior under extreme conditions can be derived. At present, a large reservoir of normal and able men whose futuristic activities will be the natural extension of their previous assignments is available.

Only a few remarks will be made concerning the holding facilities of spacefliers. Again, they will be based on the assumed similarity between spaceflight and assignment to unusual missions. Holding facilities for German combat pilots were provided in several health resorts. Most of these centers, which were convalescent hospitals and rest camps adequately staffed and equipped for fliers returning from dangerous combat missions, offered the best recreation facilities available at that time. Between and prior to their tours of duty, the men reported that contact with their families, sports and athletics (particularly skiing and mountain climbing), and music helped most in relieving tension and preparing them emotionally for the dangerous missions.

Family Life

At all these places, the fliers wore civilian clothes and were allowed to set up their own households and live with their families. However, they were under strict medical supervision and encouraged to participate in regular instruction and duties. Although each camp had sports facilities, these activities were not strictly controlled. Participation was entirely voluntary and not enforced by the authorities. The stay was limited to a period of three weeks, but it could be extended for medical reasons.

Naturally, the holding of astronauts poses some unique problems, differing considerably from those of combat



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pilots. First of all, they will be subject to a more rigorous training program, which, if not properly designed, could harm their initial state of motivation. At the present state of the art, they will actively participate in the development of specialized training equipment and devices, keep track of new research findings in the area of human factors and space medicine, structural design of vehicles and capsules, associated equipment, propulsion systems, and guidance and control techniques. Simultaneously, the indoctrination and training procedures will parallel the gradual progress in the development of the final system. This method of indoctrination and familiarization will not only serve to maintain the astronaut's interest in his future mission, but will even help to increase his eagerness to fly the vehicle when his time arrives.

Kept Busy

Secondly, there is quite a difference in holding time between our example and the early astronauts. In this case, the waiting period may amount to 12 or more months. We know from psychological studies of combat pilots that motivation and morale decrease almost proportionately with long periods of idleness. Hence the astronauts must be kept busy and active in a sensible, stimulating way.

Another problem concerns familiarization with hazardous activities. One school of thought on this question wants the candidates to be babied and kept away from all events that may scare them or give rise to traumatic experience. Another maintains that the future spaceflier has to go through all the coming events, including emergency training and familiarization with potential dangers. I personally feel that realism provides the best basis for reliable performance, and that the man who may "chicken out" because he witnesses a booster failure is a poor risk anyway. It seems to me that the best conditioning during holding consists in letting the man have the whole and true feedback through his environment, and that we can expect confidence in both men and equipment only if we are honest and sincere throughout all the preparations. In this way, we let the man know that we are concerned about his safety. This will best serve to strengthen his belief in the success of the operation.

On the other hand, everything must be done to keep the astronaut from becoming a prima donna. Spaceflight is neither a circus stunt nor a medical experiment. Early flights will, of course, be predominantly research operations in which quantitative physiological data will be recorded during actual flight. However, the astronaut, even when "wired," should not be considered or treated as a biological specimen but as a test pilot on a special mission which later will turn into a routine performance.

Although it is the right of the American press and public relations people to inform the nation about important steps in the exploration of space, there is an imminent danger of overpublicizing current activities, and this can hurt the astronauts more than anything else. These men deserve the right of privacy.

Privacy Necessary

About a year ago, Don Conover suggested that all candidates for spaceflight should be screened carefully to make sure that they will be able to withstand the sociological pressure of having been the first men in outer space. He said that they will first have to satisfy scientists that they can "fight off publicity barrages, a swollen head, and the Ed Sullivan Show." We have a high responsibility in securing their normal frame of mind, family life, and personal happiness—all of which could be seriously jeopardized by undue excitement and publicity.

While the atmosphere in which the astronauts live should be liberal and without outside pressure, strict medical supervision is mandatory during the entire holding period. Regular physical checkups for the astronauts, as well as family members, are mandatory. The best provision for mental health is a natural habitat. The men should have the experience of normal and gradual progress. This includes a new baby in the family, as well as a new space capsule in the hangar. During the last weeks before flight, they will be separated and cared for through procedures similar to those which combat pilots undergo prior to their tours of duty. The preliminaries should be accomplished without undue excitement or tension.

There is some concern among the people responsible for spacecraft staffing that a certain number of candidates (the percentage is still unknown) may have to be eliminated or will withdraw on their own request. We have to face this fact, because there will always be attrition due to unforeseen events or human weakness. No psychological or psychiatric test system can prevent this, because changes of motivation and decision are so typically human. Man will always have to cope with anxiety and fear, which may cause breakdown or resignation. He is, on the other hand, also capable of such emotional experiences as pleasure and joy—the most gratifying rewards of a successful mission.

(Ed. Note: A complete list of references for this paper is available from ARS Headquarters.) ♦♦

Javelin Instrument Package

Lockheed scientists Martin Walt and John Cladis inspect the 15-lb instrument package designed by the Missiles and Space Div. for probing the Great Radiation Belt, in the Air Force Special Weapons Center's Project Javelin, an aftermath of the Operation Jason phase of the Argus project held in the fall of 1958. SWC launched four of these Lockheed instruments on four-stage Aerolab rockets.

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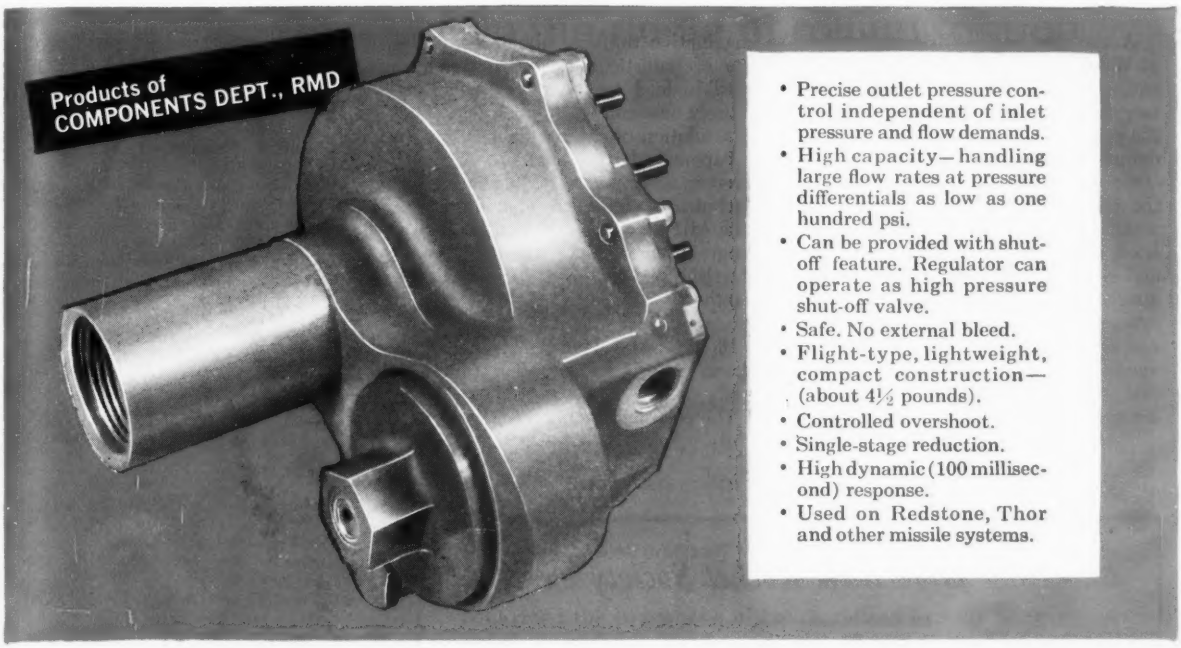

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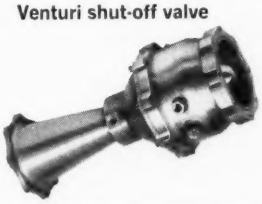
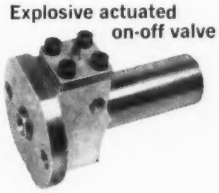


Explosive actuated on-off valve



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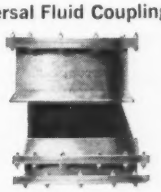
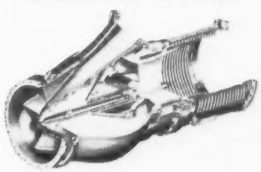


Disconnect-Check valve



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ARS news

Program Set for Classified Ballistic Missile Defense Conference at Williamsburg, Feb. 17-19

A classified ARS-ARPA conference at Williamsburg, Va., Feb. 17–19 will concentrate on the most crucial military problem facing the U.S. today—the problem of developing an effective defense against ballistic missiles.

Co-sponsored by ARS and ARPA, the three-day meeting, all sessions of which are classified SECRET, has been organized to acquaint scientific and engineering groups from industry, government, and universities with the nature and seriousness of the problem, and what is being done and still remains to be done to insure its eventual solution. It is hoped that the meeting will stimulate interest in and imaginative thinking about the problem of ballistic missile defense, and possibly lead to the development of entirely new concepts which may lead to a solution of the problem.

Papers to be presented at the conference were selected by five ARS Technical Committees in conjunction with ARPA under the direction of ARS Program Committee Chairman Brooks Morris of Marquardt. Participating are the Communications, Missiles and Space Vehicles, Ion and Plasma Propulsion, Physics of the Atmosphere and Space, and Instrumentation Committees.

The complete program for the meeting, to be held in Phi Beta Kappa Hall College of William and Mary in Williamsburg, follows:

Wednesday, February 17

BALLISTIC MISSILE DEFENSE PROBLEM

9:30 a.m.

Keynote Address: Brig. Gen. A. W. Betts, Advanced Research Projects Agency, Washington, D.C.

✦Instrumentation, Detection, and Tracking, W. R. Hutchins, Raytheon Co., Washington, D.C.

✦The Interception Problem, R. J. Volluz, Lockheed Missile Systems Div., Sunnyvale Calif.

✦Interception of Satellites, G. L. Mitcham, Institute for Defense Analyses, Washington, D.C.

✦Kill Mechanisms, Wade Blocker, Ramo-Wooldridge, Div., Thompson Ramo Wooldridge, Inc., Los Angeles, Calif.

DECOY DISCRIMINATION

2:30 p.m.

Chairman: W. R. Hutchins, Raytheon Co., Washington, D.C.

✦Nike-Zeus System (Author to be announced) Bell Telephone Laboratories, Whippany, N.J.

✦Infrared, Camille Schaar, Bendix Aviation Corp., South Bend, Ind.

✦Radar, John Whitman, Advanced Research Projects Agency, Washington, D.C.

✦New Test for Mass, Frank Manov, Electro-Optical Systems, Inc., Pasadena, Calif.

Thursday, February 18

SOME CURRENT BALLISTIC MISSILE DEFENSE SYSTEM DEVELOPMENTS

9:30 a.m.

Chairman: W. R. Hutchins, Raytheon Co., Washington, D.C.

✦Ballistic Missile Early Warning System, Brainerd Holmes, Radio Corporation of America, Moorestown, N.J.

✦Midas, J. Knopow, Lockheed Missile Systems Div., Sunnyvale, Calif.

✦High Frequency Detection, W. Thaler, Office of Naval Research, Washington, D.C.

✦Nike-Zeus (Author to be announced)

THE PROGRAM OF ACQUIRING INFORMATION ON THE BALLISTIC MISSILE DEFENSE PROBLEM

2:30 p.m.

Chairman: W. R. Hutchins, Raytheon Co., Washington, D.C.

✦Range Measurements-Optical, Harold Yates, Barnes Engineering Co., Stamford, Conn.

✦Range Measurements—Radio Frequency, R. Leaderbrand, Stanford Research Institute, Menlo Park, Calif.

BANQUET

7:00 p.m. **Motor Lodge Dining Hall**

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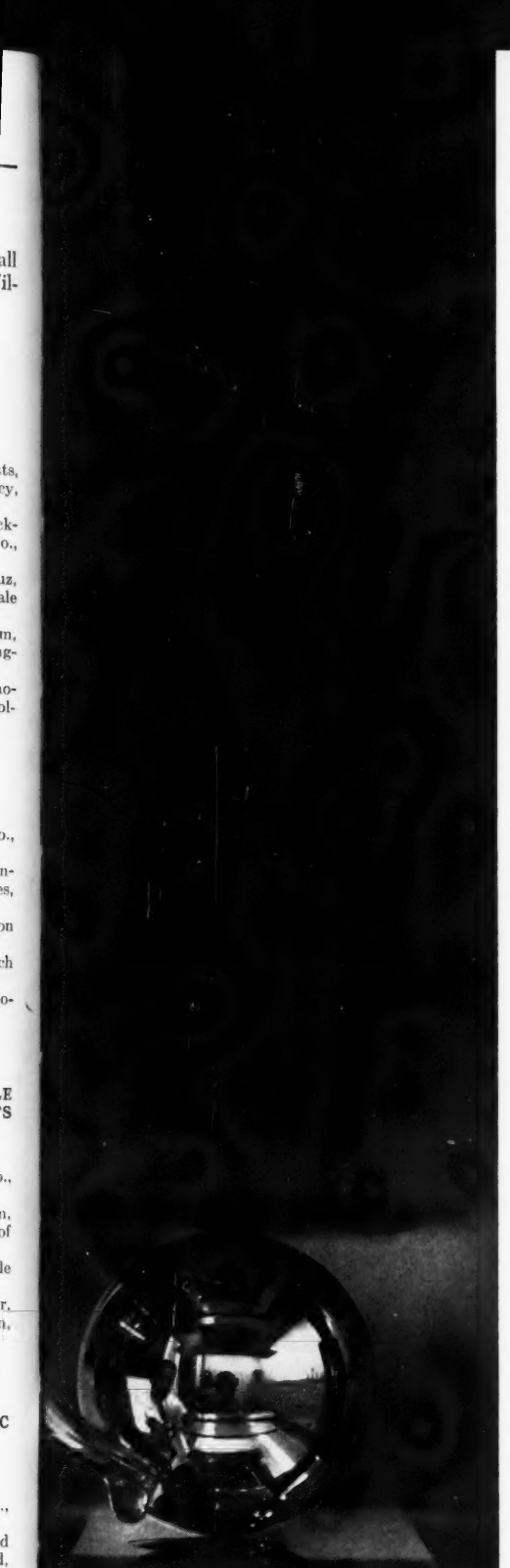
One of a series

On the riddle of rolling friction

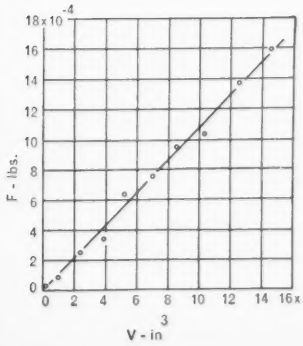


It doesn't take much to roll a hard ball across a hard, smooth, level surface – actually only about 0.00001 times the normal force acting vertically on the ball. But by careful measurement of this tiny rolling force, scientists at the General Motors Research Laboratories are helping to unravel the riddle of rolling friction.

An important relationship recently uncovered in this fundamental study: the rolling force is proportional to the volume of material that is stressed above a certain level. As a result, a GM Research group have not only confirmed the hypothesis of *how* a rolling ball loses energy (Answer: elastic hysteresis) but also have learned *where* this lost energy is dissipated (Answer: in the interior of the material, not on the surface). Mathematical analyses have indicated the exact shape of the elastically stressed volume in which all the significant frictional loss takes place.

The purpose of friction research at the GM Research Laboratories is to learn more about the elastic and inelastic behavior of materials. This knowledge – of academic interest now – will eventually give GM engineers greater control of energy lost through friction. This is but one more example of how General Motors lives up to its promise of "More and better things for more people."

General Motors Research Laboratories
Warren, Michigan



Relationship of rolling force to elastically stressed volume.

Assistant Director of Defense Research & Engineering (Air Defense)
Department of Defense, Washington, D.C.

Friday, February 19

PHYSICS AND THE BALLISTIC MISSILE DEFENSE PROBLEM

9:30 a.m.

Chairman: W. R. Hutchins, Raytheon Co., Washington, D.C.

✦Recent Physics Developments Related to Ballistic Missile Defense, J. W. Bond Jr., Institute for Defense Analyses, Washington, D.C.

✦Properties of the Upper Atmosphere, Robert Jastrow, National Aeronautics & Space Administration, Washington, D.C.

✦Composition of Outer Space, Francis Johnson, Lockheed Missile Systems Div., Sunnyvale, Calif.

✦High-Altitude Rocket Exhaust Radiation Measurements, R. G. Walker, Turney Neu, and R. E. Hunter, Air Force Cambridge Research Center, Cambridge, Mass.

✦Nuclear Weapons and Their Effects at High Altitudes, H. Mayer, E. H. Plesset Associates, Los Angeles, Calif.

PLASMA PHYSICS AND THE BALLISTIC MISSILE DEFENSE PROBLEM

2:30 p.m.

Chairman: W. R. Hutchins, Raytheon Co., Washington, D.C.

Experts in upper-atmosphere physics and plasma physics will discuss the challenge of applying the latest theoretical and experimental concepts in their fields to possible solution of the ballistic missile defense problem.

ARS GSE Conference in Detroit Shaping Up

B. J. Meldrum of Chrysler Missile Div. (left), general chairman of the forthcoming ARS GSE Conference, discusses plans for the meeting with Fred Klemach of Vickers (center) and E. A. Nielsen of Chrysler, president of the ARS Detroit Section.

Plans for the ARS Ground Support Equipment Conference in Detroit, March 23–25, are nearing completion. Sponsored jointly by the ARS Test Facilities and Support Equipment and Logistics and Operations Committees, the conference will have as its theme "GSE in Transition."

Following this theme, technical sessions have been arranged so as to begin with a review of current operational and production ground support equipment, emphasizing knowledge gained from first-generation hardware. Following in order will come a review of newer R&D systems and the basis of concepts employed in second-generation systems and, finally, an examination of the newest ideas and developments in specific GSE areas and future trends.

An unusual feature of the conference will be the field trips scheduled for each afternoon during the meeting. Technical sessions will be held each morning and will be followed by luncheons, but the afternoons have been left open for the trips. A special unclassified evening session is planned for March 23.

ARS members attending the conference will have a choice of classified tours of the Army Ordnance Tank and Automotive Command, Michigan Ordnance Missile Plant and Burroughs Corp., or unclassified tours of the GM Technical Center and Ford Scientific Laboratories.

Big Expansion Underway at Minnesota Mining & Mfg. Co.

Minnesota Mining & Mfg. Co. announced that it has 17 major construction projects underway in eight states as part of its multimillion-dollar-a-year master construction program. Latest project undertaken, and scheduled for 1962 completion, is a 14-story office building and attached cafeteria on a 265-acre tract east of St. Paul, an area which the company says will be needed to meet anticipated 3M growth in the next 10 to 16 years.

URC of Menlo Park Building Two Space-Age Facilities

United Research Corp. of Menlo Park, Calif., a new United Aircraft subsidiary formed to carry out R&D in solid and liquid propellants, rockets, and advanced propulsion, has begun construction of a research and engineering center in Sunnyvale and a development and test center near San Jose.

The research and engineering center will stand on a 25-acre site and initially house corporate headquarters and research and development laboratories. The development and test center will take in 3200 acres and will be utilized for solid-propellant development. It will have extensive test facilities for both solid and liquid rocket engines, including vertical and horizontal test stands.

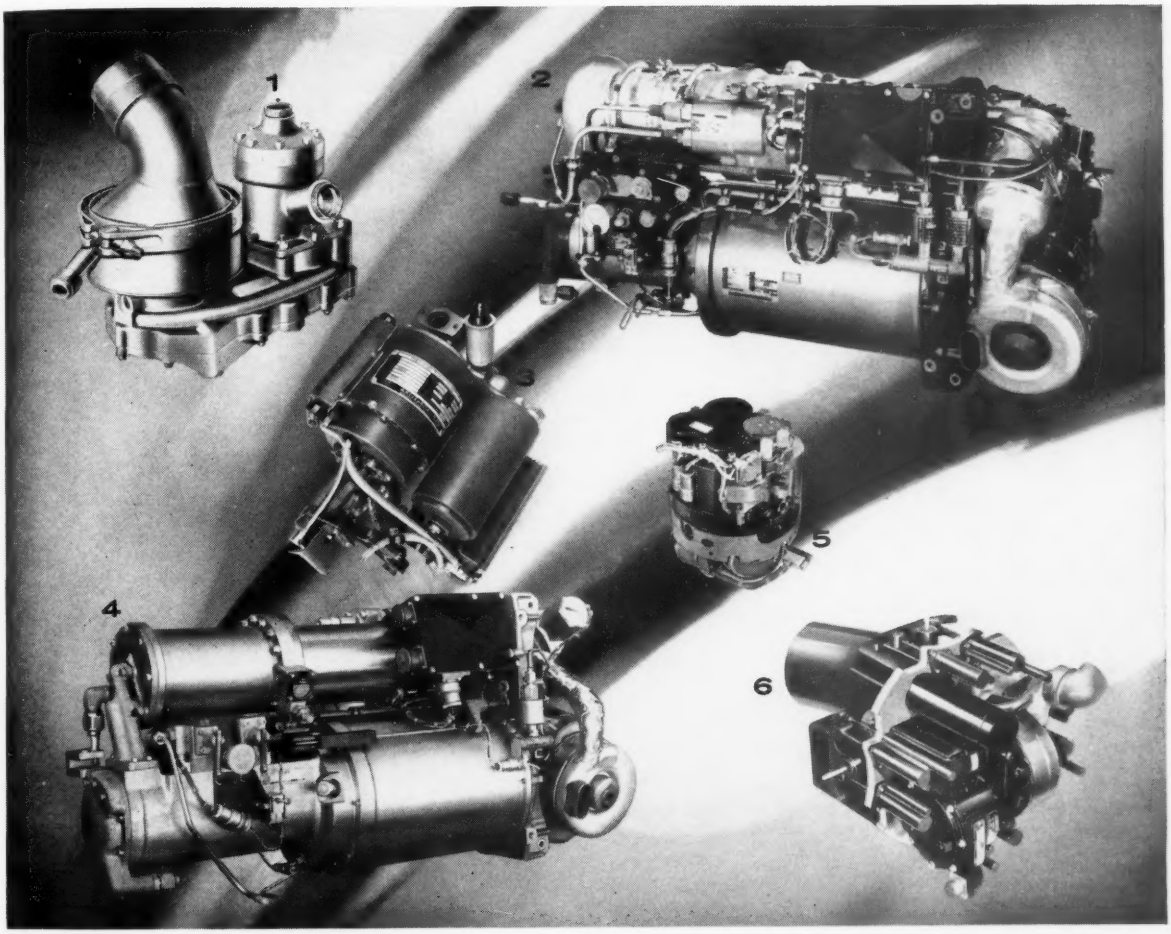
Six More Companies Become ARS Corporate Members

Six more companies have become corporate members of the AMERICAN ROCKET SOCIETY. The companies, their areas of activity, and those named to represent them in Society activities are:

Claremont Pigment Dispersion Corp., Rosyln Heights, N.Y., manufacturer of high-temperature resistant coatings and corrosion inhibitors, metal pigmented plastics, metallic paints and printing inks, fluorescent and phosphorescent coatings, and high-temperature resistant pigments for thermosetting and thermoplastic resins. Named to represent the company in ARS activities are Hal-Curtis Felsher, vice-president, R&D; Walter J. Hanau, chief chemist; and Richard Carleton Bradshaw, research associate.

National Cash Register Co., Dayton, Ohio, with broad interests in missile and rocket fields, conducts research in the fields of propellants, propellant protection and isolation, guidance, and electronic componentry for guidance. Representing the company are B. K. Green, manager of chemical research; P. D. Bouffard, section head, Fundamental Research Dept.; E. F. Hare

DELIVERED—thousands of missile APUs



1. *Solid propellant—hydraulic output* 2. *Liquid propellant—hydraulic and electric output* 3. *Solid propellant—electric and mechanical drive output*
4. *Liquid propellant—hydraulic and electric output* 5. *Solid propellant—hydraulic and electric output*
6. *Solid propellant—hydraulic, electric and steering outputs*

AiResearch has designed, developed, manufactured and delivered thousands of missile accessory power units. Extremely reliable and lightweight, these various solid and liquid monopropellant APUs are completely self-sustaining within the missile system. Designed to minimum space and weight requirements, they are built to withstand high G loading and severe temperature extremes.

The several units pictured above provide hydraulic, electrical and/or steering surface control depending on the customer's requirement. Delivered horsepower ranges from 1.2 to 35 h.p. over hot gas operating durations from 30 seconds to 20 minutes. Electrical regulation is maintained as closely as ±½%. A significant advance in missile APUs is unit #6 pictured above. This package represents the first integrated hydraulic and electrical power unit providing a steering surface actuation system.

These tailored systems utilize the extensive hardware experience and complete laboratory, test and production facilities of AiResearch needed for quick and efficient quantity production of complex APU systems. AiResearch is the world's largest and most experienced manufacturer of lightweight turbomachinery—the key component of its APU systems. Your inquiries are invited.

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Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

On the calendar

1960

Feb. 1–4	ISA Instrument-Automation Conference and Exhibit, Rice Hotel and Sam Houston Coliseum, respectively, Houston, Tex.
Feb. 3–5	IRE Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles.
Feb. 4–6	ASM Golden Gate Metals Conference on "High Strength Steels," Fairmont Hotel, San Francisco.
Feb. 4, 11, 18, 25	Gas Dynamics Colloquium on Steady-State Magnetohydrodynamic Experiments, Departures from Equilibrium in Mixing Regions, Relaxation Times in Gases, and A New Application for the Hydraulic Analogy, respectively, Northwestern Univ., Evanston, Ill.
Feb. 16–18	First National Symposium on Nondestructive Testing of Aircraft and Missile Components, sponsored by Society for Nondestructive Testing and Southwest Research Institute, Hilton Hotel, San Antonio, Tex.
Feb. 17–19	**ARS-ARPA Ballistic Missile Defense Conference, SECRET, College of William and Mary, Phi Beta Kappa Hall, Williamsburg, Va.**
Feb. 18–19	AIEE Symposium on Engineering Aspects of Magnetohydrodynamics, Univ. of Pennsylvania, Philadelphia.
Feb. 18–20	National Society of Professional Engineers Winter Meeting, Broadview Hotel, Wichita, Kan.
March 3, 10, 31	Gas Dynamics Colloquium on Combustion Instability in Solid Propellant Rocket Motors, High Altitude Aerodynamics in Relation to Experimentation, and Electrical Propulsion Systems, respectively, Northwestern Univ., Evanston, Ill.
March 6–9	ASME Gas Turbine Power and Hydraulic Conference, Rice Hotel, Houston, Tex.
March 9–10	Symposium on Processing Materials for Re-Entry Structures sponsored by Midwest Chapter of The Society of Aircraft Material and Process Engineers, Miami Hotel, Dayton, Ohio.
March 9–11	Conference on Mechanical Properties of Engineering Ceramics, North Carolina State College, sponsored by Office of Ordnance Research and NCSC.
March 9–11	ISA Temperature Measurement Symposium, Deshler Hilton Hotel, Columbus, Ohio.
March 23–25	**ARS Ground Support Equipment Conference, Statler-Hilton Hotel, Detroit.**
March 29–31	ASME American Power Conference, Sherman Hotel, Chicago, Ill.
April 3–8	EJA Sixth Nuclear Congress, with ISA cooperating, New York, N.Y.
April 6–8	**ARS Structural Design of Space Vehicles Conference, Santa Barbara Biltmore, Santa Barbara, Calif.**
April 6–8	National Meeting of the Institute of Environmental Sciences, Biltmore Hotel, Los Angeles.
April 21–22	AIME Southwest Metals and Minerals Conference on Metals and Minerals for the Space Age, Ambassador Hotel, Los Angeles.
May 2–5	ISA Sixth National Flight-Test Symposium, San Diego, Calif.
May 3–5	IRE-AIEE Western Joint Computer Conference, San Francisco.
May 9–11	ISA Third National Power Instrumentation Symposium, San Francisco.
May 9–12	**ARS Semi-Annual Meeting and Astronautical Exposition, Ambassador Hotel, Los Angeles.**
May 9–12	ISA Instrument-Automation Conference and Exhibit, San Francisco.
May 23–25	**ISA, ARS, IAS, AIEE National Telemetering Conference, Miramar Hotel, Santa Monica, Calif.**
May 24–28	Japanese Rocket Society 2nd International Symposium on Rocketry and Astronautics, University Club, Tokyo.
June 15–17	1960 Heat Transfer and Fluid Mechanics Institute, Stanford Univ., Stanford, Calif.
July 21–27	3rd International Conference on Medical Electronics, sponsored by Institution of Electrical Engineers and International Federation for Medical Electronics, Olympia, London.
Aug. 15–20	**11th International Astronautical Congress, Stockholm, Sweden.**
Aug. 31–Sept. 7	10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.
Oct. 20–21	Hypervelocity Projection Techniques Conference, Univ. of Denver, Colorado.
Dec. 5–8	**ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.**

Jr., senior research chemist, FRD; Donald A. Burns, senior research chemist, FRD; and G. J. Wilson, director of research.

Otis Elevator Co., Defense & Industrial Div., Brooklyn, N.Y., engaged in design, development, and fabrication of ground support equipment for missile guidance and control subsystems and training and simulation equipment for aircraft and missile firing personnel. Representing the company are Marvin J. Gaut, general manager; Joseph Browdy, mechanical engineer section chief; Wayne B. Holmes, manager, West Coast operations; Rosewell M. Huff, manager, military customer relations; and Frederick J. McKeown, assistant manager, military customer relations.

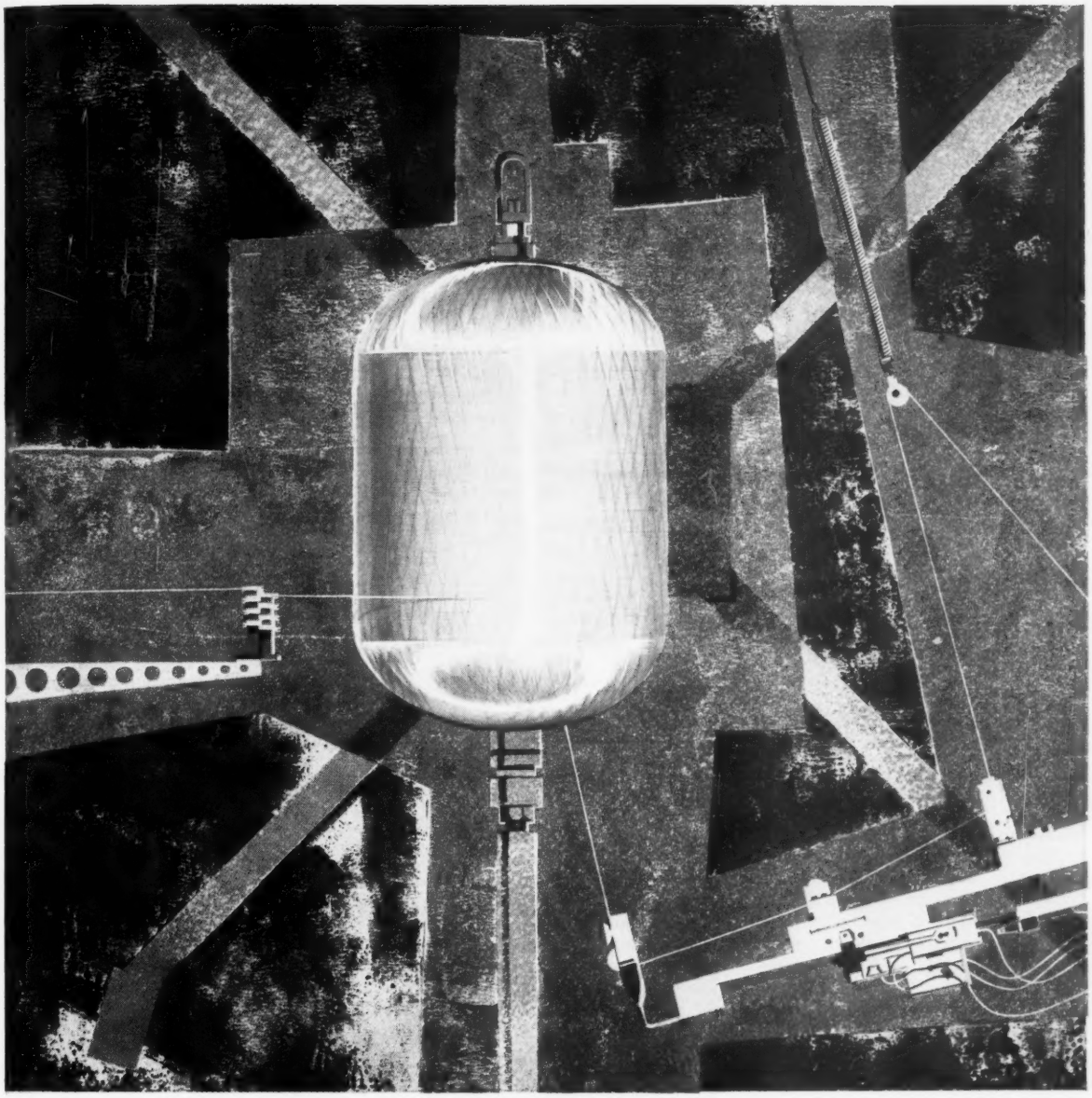
Resistoflex Corp., Roseland, N.J., producer of flexible high-temperature high-pressure Fluoroflex-T fluid carrying systems; Teflon transfer hose, lined pipe, bellows, and related Teflon products. Representing the company are I. D. Press, vice-president, engineering; C. A. Carlsen, manager, aircraft sales; F. Brock, assistant manager, aircraft sales; and G. G. Bell, manager, Western Div.

Swedlow, Inc., Los Angeles, Calif., manufacturer of high-temperature plastics, ablation materials; and honeycomb core. Representing the company are Dave Swedlow, president; John P. Endicott, executive vice-president; John G. Stansbury, technical director; W. H. Face, contracts director; and Carey Carpenter, technical service manager.

Texas Instruments Inc., engaged in missile and space vehicle communications, detection, instrumentation, guidance, and flight control; heavy radar systems, electronic surveillance (IR, radar, optical, etc), and antisubmarine systems and studies. Named to represent the company in ARS activities are W. F. Joyce, vice-president; H. J. Wisseman, assistant vice-president; P. J. Gomez, manager, Missiles and Optics Dept.; Leland D. Strom, chief engineer, R&D; and A. L. Coulson, manager, Service Engineering Dept.

ARS Membership Rises To 15,000 during 1959

The addition of 4559 new members during 1959 brings ARS total membership above the 15,000 mark. The number of new members added during the year almost matched the 4593 members added in 1958. ARS corporate membership grew to 154 during the year.



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1960 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
Feb. 17–19	Ballistic Missile Defense Conference	Williamsburg, Va.	Past
March 23–25	Ground Support Equipment Conference	Detroit, Mich.	Past
April 6–8	Structural Design of Space Vehicles	Santa Barbara, Calif.	Past
May 9–12	ARS Semi-Annual Meeting and Astronautical Exposition	Los Angeles, Calif.	Past
May 23–25	National Telemetering Conference	Santa Monica, Calif.	Feb. 1
Aug. 15–20	11th International Astronautical Congress	Stockholm, Sweden	April 15
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Aug. 25

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

SECTIONS

Central Indiana: At the Nov. 24 meeting, 90 members of the Section heard **Richard E. Reinnagel** of Cornell Aeronautical Laboratory present a talk entitled "Taking the Miss out of Missiles." The speaker has taken part in almost every phase of the Lacrosse development.

After a brief history of the Lacrosse missile, he emphasized reliability and detail design for the successful guided missile operation. It was brought out that a guided missile system is designed to meet a well-defined military need. There is great danger, he said, that we could become committed to an impractical system due to the pressure of schedules. This will not happen if experience and mature judgment are used in establishing the detail design of each component and circuit of the missile system. Reliability will then be an inherent part of the system.

Officers for the calendar year 1960 were announced. They are H. L. Karsch, president; T. M. Englehart, vice-president; R. E. Sullivan, secretary; and J. L. Emley, treasurer. T. F. Nagey, the outgoing president, was elected to the Board of Directors.

—**Marshall H. Fisher**

Chicago: Editor of the monthly newsletter started by the Section last fall is **Milton Goldstein,** dean of the American Institute of Engineering and Technology. "Goldie" is also faculty adviser to an ARS student chapter being formed there.

Cleveland-Akron. Our new Section publication, "Briefings," has been successfully launched, and will be published four times a season. The primary objective of "Briefings" is to keep members informed of current activities and thereby stimulate greater membership interest and participation.

"Torpedo Propulsion Systems" was the subject of **John F. Brady's** talk at the December meeting. Mr. Brady's tactful comparison of torpedo propulsion systems with missile and aircraft systems made the presentation quite interesting. The talk, given at Clevite Corp., was supplemented by a display of underwater ordnance equipment.

At the January dinner meeting, **Tibor F. Nagey,** director of research at GM's Allison Div., spoke on "Space Power Systems" before a joint ARS-ASME group, giving some emphasis to the Sterling-cycle generator proposed by Allison for space vehicles.

—**Richard G. Gido**

Columbus: The initial session of the Section in the 1959–60 season was a dinner meeting held jointly with the local IAS section at the Desert Inn on Sept. 15, with approximately 105 members and guests of both organizations in attendance. The guest speaker for the evening was **Clem C. Weissman,** Physical Science Administrator of the Development Planning Group, Office of the Deputy Chief of Naval Operations for Development. He spoke on "Weapon System Concepts," outlining the broad functions performed by any weapon system and related these to the problems of naval warfare.

The October meeting was held at Battelle Memorial Institute with approximately 40 members and guests present. Guest speaker for the meeting was **Lovell Lawrence Jr.,** chief engineer of the Advanced Projects Organization of Chrysler Corp., who spoke on "Astro, A Satellite Navigation System." Mr. Lawrence described his design of a system of three small, semipermanent satellites in circular polar orbits about 600 miles up which would serve as aircraft navigation beacons by transmitting a radio signal correlated with a time signal. He stated that an aircraft carrying a receiver to pick up these signals and a simple computer could determine its position within an accuracy of 1 mile anywhere on earth. A spirited question period followed Mr. Lawrence's presentation.

The November meeting, held at Battelle, with 32 members and guests present, heard a summary of the results of the Propellants Conference held in Columbus the past summer and a report on current activities of the Columbus Technical Council, which included a request for nominations for the selection of a Columbus "Engineer of the Year" and for a progress report on vocational guidance activities in the local schools. It was announced that the Section has decided to coordinate the participation in these educational activities with the local IAS section.

Guest speaker at this meeting was **Merle Smallberg,** manager of special projects for the Astro Div. of Marquardt Corp., who discussed "Hypersonic Ramjets." He indicated that this type of airbreathing powerplant should have an efficiency advantage over a rocket for powering such vehicles as hypersonic transports.

The December meeting, again held at Battelle, heard a report on activities at the recent ARS Annual Meeting. The technical presentation of the evening was given by **Jon W. Eberle,** research associate at the Ohio State Univ. Antenna Laboratory, whose topic was "Missile Guidance and Fire Control Systems." Because many in the audience had little detailed familiarity with radar systems, he graciously began with a basic description of types of radar; outlined the characteristics

BECAUSE THIS FAILED
the bird didn't fly

FOR SUCH PROBLEMS more nondestructive tests can help

Often the reason why a missile fails is clear enough — after the failure. A component or system didn't function.

But this may be only half the answer.
Why did the system or component fail?

Was there an unknown defect, crack or leak or metallurgical abnormality that could have been discovered—with the proper nondestructive testing system? Or was the part or material being "worked" within a hair-line of maximum capacity of known *perfect* samples or "handbook" values—without full nondestructive testing? The nondestructive test is entirely different from a physical overload test, and proves out different things!

When the designer must assume near perfection to attain planned performance, the integrity of every element in the system, and of every material and part must be nondestructive tested—proved—and known. At present does the designer know?

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Where no existing systems meet the need, we are ready to work with any responsible agency in an authorized Research and Development program. We have 30 years of specialized testing knowledge, and a dozen or more testing systems.

We sincerely believe that lack of full use of proper nondestructive testing is a problem of national importance that must be met head-on. We offer our help.

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MAGNAFLUX MAGNAGLO to test magnetic materials for cracks, seams, etc.
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Touring a Nike-Ajax Installation

Last fall, these members and guests of the Fort Wayne Section toured the Nike-Ajax installation at Wheeler, Ind., which is the Southeastern end of the Chicago-Gary defense system. At the far right, from left to right, are the installation's commander and host for the occasion, Lt. Carter M. Kolb Jr., U.S.A.; its executive officer, Lt. Fleming; and 1960 Section President, Paul D. Rogers.

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and limitations of the various kinds of antennas and beams, and then gave a detailed explanation of pencil beams, the type most useful for guidance, and discussed the angular accuracies obtainable in tracking. The meeting concluded with a question period, during which the effects on personnel and on other equipment of high-energy radar outputs were discussed at some length.

Connecticut Valley: At a meeting of the Section held on Dec. 8 at Trinity College in Hartford, **Capt. L. E. Harrington,** U.S.A., commander of Battery A, Second Missile Battalion, East Windsor, presented a talk on the Nike-Hercules and Nike-Ajax missile systems. Capt. Harrington, assisted by **Lt. R. W. Fisher,** explained in detail the air defense system now in operation using the Nike installations. The functions of Dew Line, Sage, and a typical Nike-Ajax missile system were outlined for a hypothetical attack by enemy aircraft on the city of Hartford. Also, a short film was shown describing the effectiveness of the Nike-Hercules missile in destroying high-altitude jet target planes.

—Frank Gabron

Holloman: The Section held a dinner meeting at the Desert Aire in Alamogordo on Dec. 22, and in spite of the conflict with Christmas activities attendance was excellent. Retiring president Knox Millsaps made a brief farewell speech, which sparkled with his usual humor, and then introduced the new Section president, H. J. Von Beckh. Dr. Von Beckh paid tribute to Dr. Millsaps, mentioning the growth and performance of the Section under his leadership. He then introduced the guest speaker for the evening, **S. Fred Singer,** professor of physics at the Univ. of Maryland and a pioneer in astronautics, having, for instance, proposed the Mouse Project as early as 1952.

In his talk, titled "The Scientific Challenge To Man's Space Flight," Dr. Singer covered both his specialty, space radiations, and other problems man must face in spaceflight—radiations trapped about the earth, the cosmic radiations of which very little is known as yet, re-entry, rocket reliability, and weightlessness. This far-ranging and interesting discussion was received enthusiastically.

—Harry H. Clayton

Pacific Northwest: At a December meeting, the following new officers were elected: D. M. Van Ornum, president; F. D. Reynolds, vice-president; R. W. Carkeek, secretary; and R. L. Farmer, treasurer.

—Regis A. Hacherl

Southwestern Michigan: In December, a meeting was held by the Section for the purpose of receiving its charter. **Charles W. Williams** of Chrysler Missile Div. made a memorable presentation and also gave a program based on Chrysler's missile work, showing slides and films of Jupiter and Redstone manufacture and flight-tests from Canaveral. The film was an extremely good one, and we recommend it to other Sections as a general source of public information.

At this meeting, the following newly elected officers, who took over immediately, were announced: John Moeller, president; Robert E. Angerman, vice-president; and V. Tsien, secretary-treasurer.

—John D. Moeller

St. Louis: At an early meeting in December, held in the briefing room of the McDonnell Aircraft Corp., **Robert E. Rohtert,** chief of wind tunnels for McDonnell, addressed the membership on "The MAC 'Hot-Shot' Wind Tunnel," going over its design, operation, and use. His presentation was supplemented by slides and a color film of the Tullahoma "Hot-Shot" tunnel in operation.

Later in December, **Curtis Johnston,** test conductor for Convair at Cape Canaveral, addressed a joint meeting of this and the local section of IAS on various launchings involving Atlas, and showed some excellent movies and slides. Despite bad weather, an overflow crowd attended the meeting, and had the pleasure of this exciting presentation and a lively discussion period afterwards.

—Albert E. Cohen

University Park: The December meeting of the Section was held on the campus of Pennsylvania State Univ. in joint session with the local ASME section. At this meeting, **E. N. Petrick** and **H. W. Szymanowski** of the Curtiss-Wright Research Center, Quehanna, Pa., discussed the state of the art of propulsion systems proposed for spaceflight operations. Their discussion, illustrated with slides and a film, was devoted primarily to electrical propulsion devices, including plasma jets, the plasma rail, and ion rockets. Dr. Petrick is chief of the advanced propulsion group at Quehanna. Dr. Szymanowski, a native of England, has a broad background in reciprocating engines, the "Whittle" gas-turbine engine, ramjets, rockets, and ion engines. Their talk, interesting and informative, was appreciated by the audience.

—M. Zane Thornton

Wichita: The December meeting, a joint one with local sections of AIEE and ASME and the Wichita Society of Professional Engineers, heard an interesting presentation by **Leonard J. Linde,** manager of C-Stellerator Associates of Princeton, N.J., on "The C-Stellerator Fusion Research Program" and methods and equipment used to control thermal-nuclear fusion reactions.

—Dean E. Burleigh

The Denver Division of The Martin Company is continuing to expand its activities in space science and engineering. For those persons who can contribute a high degree of professional competence to these programs, Martin offers opportunities for achieving personal advancement, professional recognition and increased income.

Qualified candidates for any of the following positions must have appropriate technical degrees from accredited colleges or universities and must include details of education and professional experience plus the names and addresses of at least two professional references in their initial letter of application. These references will be checked only after we have discussed specific openings with you.

ADVANCE OPERATIONS DIVISION

Advance Planning Specialists

To be responsible for identification of future systems and subsystems and components requirements associated with military or civilian rocket and related development programs. Candidates must be familiar with key agencies and personnel. Must have ability to document findings and recommendations. Broad technical background in rocketry is essential.

ENGINEERING DIVISION

Operations Analysts

To staff new section of Technical Development Department. An initial group of ten men are needed at this time. Candidates must have sound education in applied physics or applied math and professional experience in weapon system, operations analysis.

Research Scientist for Staff of Advance Electronics Section

This man will be qualified to do work in the field of inertial guidance. Should be experienced in astro-inertial and doppler augmented inertial advanced guidance systems.

Systems Engineering Department

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(All inquiries will be held in confidence and will be answered within 14 days of being received.)

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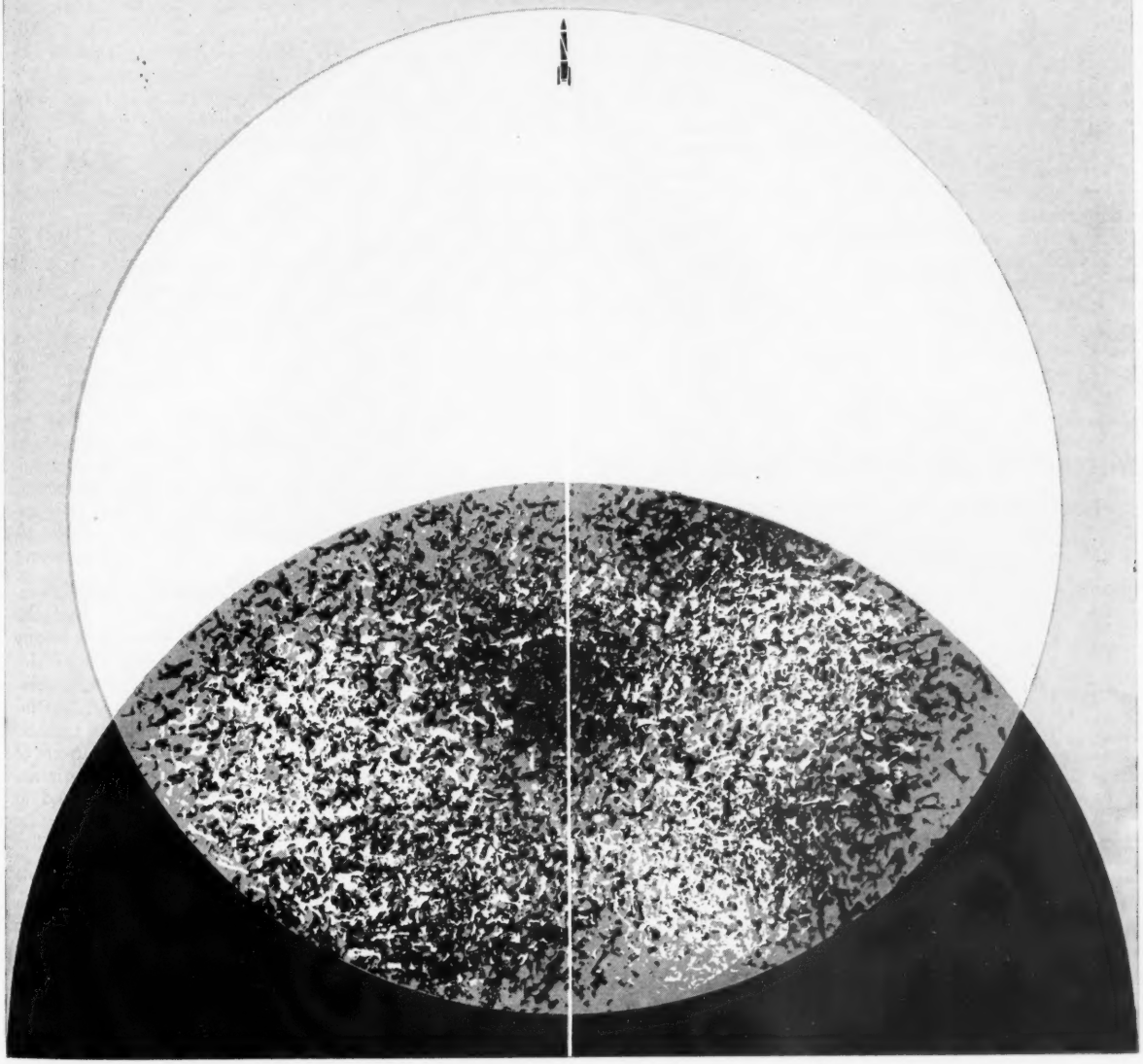

STUDENT CHAPTERS

Fairleigh Dickinson Univ.: Robert L. Randolph is the new president of the Chapter. Joe Casilli is vice-president and Carl Bartolli is secretary-treasurer.

Manhattan College: On Dec. 9, **Elliot Taylor** of Thiokol's Reaction Motors gave a lecture on the general characteristics of liquid- and solid-propellant engines. The talk was excellent, giving a broad interpretive covering of this important field of rocketry. Following the talk, there was a lively question and answer period. Our attendance was between 55 and 70 students. It would undoubtedly have been larger if the college newspaper had printed its usual schedule of events of the day.

On the agenda for next semester are the following events: Feb. 17–films, "Road to the Stars" and "Atlas ICBM," and March 23– speaker from Republic Aviation. Also there will be lectures by a member of our mathematics faculty and by a representative from GE's Missile and Space Vehicles Dept.

—Richard Simpson

Missouri School of Mines: A meeting of the proposed Missouri School of Mines Chapter was held in May of last year in order to elect officers for the coming school year. At that time, there were no members, but the usual nominating committee was set up and open nominations were accepted from the floor. The following men were elected to office: Jim D. Howard, president; James Delp, vice-president; Gary Bagby, secretary; and Joseph Lewis, treasurer.

On Oct. 7, the chapter held its first official meeting, at which **William Barnes** presented a very interesting program by Southwestern Bell Telephone. After the meeting, an informal social period was held and memberships were taken. A total of 75 memberships were received.

A joint meeting of ARS and AIEE-IRE was held on Nov. 11. **Richard T. Carlisle** from the Naval Ordnance Test Station presented a program on small-caliber rockets. At the beginning of the meeting, **James Holsen** of the St. Louis Section presented the Charter to the officers of the Chapter.

Our plans are many and varied. We hope to take some field trips and have many interesting programs lined up for the year. Our membership now totals 83 and is steadily growing. **Harry Sauer** and **Jim Smith,** our faculty advisers, have donated much time and effort in helping us get started.

—Jim D. Howard

Rensselaer Polytechnic Institute: On Dec. 10, a combined meeting of the proposed Rensselaer Polytechnic Institute student chapter and the Physics Society was addressed by **V. Josephson** of Space Technology Laboratories. Dr. Josephson spoke on current research being conducted at STL, giving particular emphasis to his major field of interest–fusion physics. He stated that he and his associates are searching not for commercial products, but, among other things, to find a new source of fuel and energy to supplement our diminishing natural resources. The deuterium-deuterium and deuterium-tritium fusion reactions, said Dr. Josephson, bear watching as sources of this energy.

—Marjorie A. Platz

St. Joseph Valley: The Chapter recently elected the following officers for the new year: B. A. Bishop, president; M. S. Ehrenberg, vice-president; L. J. Boler, secretary; and D. J. Marcotte, treasurer.

—Marvin S. Ehrenberg

Univ. of Colorado: At the December meeting, the members had the pleasure of hearing **Maurice Anthony** speak on "Trajectories and Flight Mechanics." Dr. Anthony, who at present is a research scientist at Martin-Denver, discussed problems of ballistic trajectories and the application of Newton's theories to range determinations. Refreshments were served at the close of his very interesting lecture.

—John G. Shaffer

Wayne State Univ.: At its first meeting of this school year, held in Oct., the Section heard **Claud Gage** of Chrysler Missile Div. explain the structural designing of missiles. The November speaker was **Magnus Von Braun** of the Chrysler Missile Div., who described German missile tech-

Tennessee Section Chartered

ARS President-Elect Howard S. Seifert, chief scientist of STL, presents charter for the newly formed Tennessee Section to its president, Harvey M. Cook, in dinner-meeting ceremonies held in December at the Arnold Engineering Development Center. Dr. Seifert also spoke at the meeting on the difficulties of disseminating technical information, his address titled "Is Anybody Listening?" The Tennessee Section currently has 78 members, 48 of whom are with ARO, Inc., the Air Force's operating contractor for AEDC.

Missouri School of Mines Chapter Formed

Left foreground, James Holsen, president of the ARS St. Louis Section, presents a charter to officers of the newly formed Missouri School of Mines Chapter.

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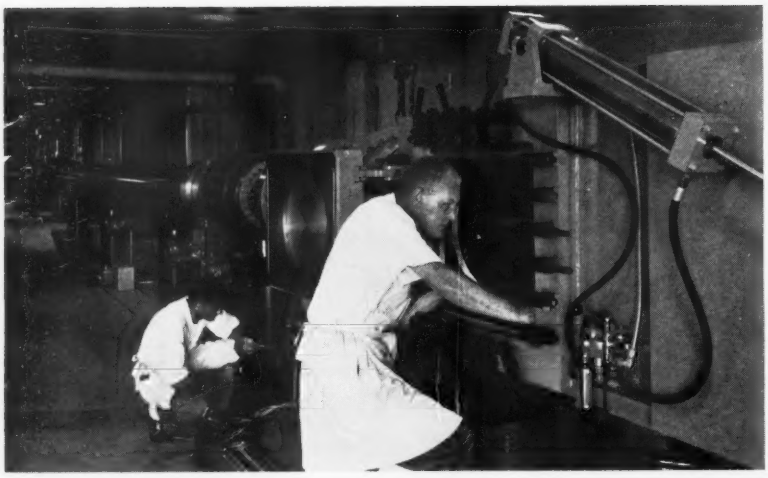


CAL Shock Tunnel in Operation

Cornell Aeronautical Lab's hypersonic shock tunnel is now in operation, testing missile and aircraft designs between Mach 5 and 16. Shown above, the tunnel, about 110 ft long, features the CAL-developed "tailored interface" technique for eliminating shockwave rebound between the end of the shock tube and the front of high-pressure gas. This technique permits maintaining a hypersonic air flow at constant speed for 15 millisec—about eight times longer than has been possible with previous tunnels, and long enough to make good measurements on models with fast-responding instruments. The CAL tunnel is available both to government and industry.

---

nology. Later in November, Chapter chairman **Charles Martin** attended the ARS 14th Annual Meeting in Washington, D.C. In December, the Chapter had a joint meeting with the student chapter of IAS. This meeting was highlighted by a talk by **Eugene Dangle** of NASA, who described and explained space vehicles with conventional and ion propulsion. One of the activities proposed for the coming year is a field trip to Chrysler Missile Div.

The Chapter officers are as follows: Charles Martin, chairman; Edward Lovell, treasurer; Victor Newton, corresponding secretary; Anthony Jankiewicz, acting vice-chairman. Charles C. Perry is faculty adviser, and Magnus Von Braun is technical adviser.

Daystrom Acquires Rights To German Missile Systems

Daystrom, Inc., will have exclusive rights in the U.S. and Canada to surface-to-surface missile system developments of Boelkow Entwicklungen, K.G., Ottobrun, Germany, according to an agreement signed by the two companies.

CORPORATE MEMBERS

Acoustica Associates acquired Ender-Monarch Corp., Garfield, N.J., manufacturer of illumination equipment, via exchange of stock. . .**American Bosch Arma Corp.** is trying a new tack in recruiting technical personnel for R&D by sponsoring a daily radio program entitled "Today in the Space Age," Monday through Friday, at 6:40 p.m. on WABC AM and FM. . .**Atlantic Research Corp.** has instituted a new materials testing service for producers and users of rocket materials, and also has ordered a $700,000 Burroughs 220 high-speed computer to service its rapidly growing volume of computer activities. . .**Ford Motor Co.'s** Aeronutronic Div. has established a field office at Huntsville, Ala. . . .**General Dynamics'** Convair-Astronautics Div. has let a construction contract for its new 18,000-sq-ft space research laboratory. . .**GE** will build a $14 million research center near Philadelphia for its Missile & Space Vehicles Dept. . . .**Grand Central Rocket Co.** will undertake a $2-million three-year expansion, adding a new solid-propellant research laboratory, an engineering building, and an administration center.

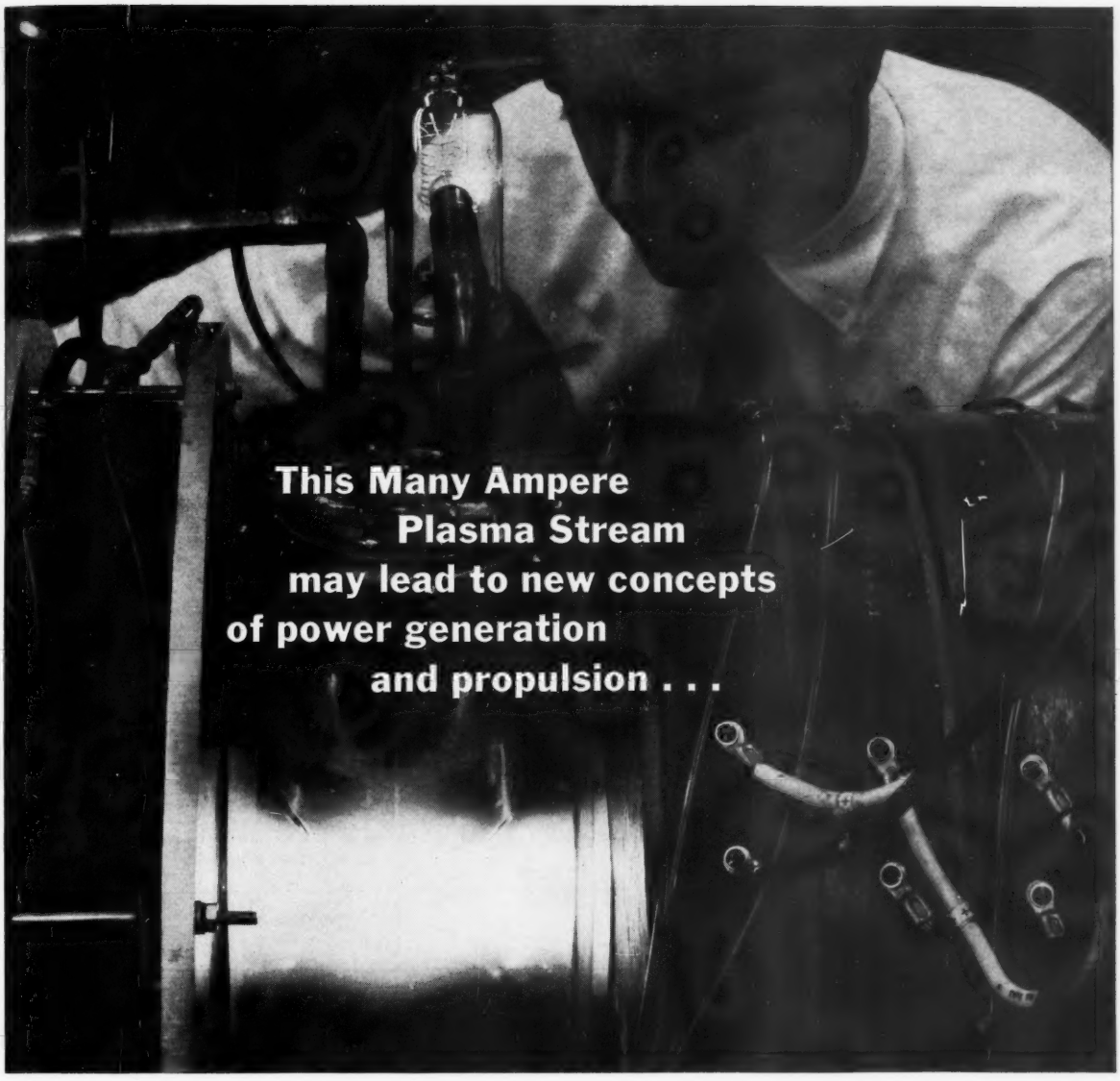
Hughes Aircraft's Technical Training Dept. in the Field Service and Support Div. graduated its 5000th student and in January marked the 10th anniversary of the training program. . .**ITT** has set up a new facility for R&D of special microwave electron tubes at its Advanced Development Lab. . .To more accurately reflect its activities, **Walter Kidde & Co.** has changed the name of its Aviation Div. to Kidde Aero-Space Div. . . .**Martin Co.** says it will consolidate all aspects of its Titan program into one division with headquarters at its Denver plant. . .**Minneapolis-Honeywell Regulator Co.** has renamed its Davies Laboratories Div., Beltsville, Md., which produces analog and digital magnetic tape systems and components, to the Industrial Systems Div.

AEC announced it will issue a permit to **North American Aviation's** Atomics International Div. for construction of a critical-experiments facility for use in connection with its Advanced Epithermal Thorium Reactor program. . .**Philco Corp.** and **CBS-Electronics** have signed a cross-licensing agreement covering manufacture and sale of semiconductors. Philco has awarded a construction contract for its new Research Center to be built on a 25-acre site in Blue Bell, Pa. . . .**Raytheon** is consolidating its government and industrial equipment service and support functions into one company-wide Electronic Services Div. The Industrial Tube Div. has been renamed the Industrial Components Div. . . .**Space Technology Laboratories** is moving its operations into a new 40-acre complex of eight buildings at 5500 El Segundo Blvd., El Segundo, Calif. . . .**Telecomputing Corp.** has acquired the assets of Phoenix Engineering and Mfg. Co., Arizona manufacturer of precision missile, aircraft, and electronic parts . . .**United Aircraft's** Hamilton Standard Div. has negotiated purchase of a 50 per cent interest in Microtecnica, Inc., Turin, Italy, manufacturer of electromechanical devices.

COMMITTEES

Human Factors and Bio-Astronautics: The latest Progress Report of the Committee, put together by Gene Konecci of Douglas, includes a rundown on the ARS Annual Meeting, with abstracts of all papers of interest to Committee members presented at the meeting.

Underwater Propulsion: Calvin A. Gongwer of Aerojet has been appointed vice-chairman of the committee, which will hold its first technical session at the ARS Semi-Annual Meeting in Los Angeles in May. ♦♦



A many-ampere source of ions, this device is believed to be the most powerful in operation in any laboratory. Already it is providing new insight into thermonuclear fusion. It may lead to new concepts in propulsion including a method of producing thrust for missions beyond the earth's atmosphere.

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ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner

Flight Propulsion Laboratory Dept.

General Electric Co., Cincinnati 15, Ohio

FLUORINE (F_2)

Fluorine is a yellow liquid which vaporizes to form a pale, greenish-yellow gas and freezes to a yellow solid and undergoes a transition to a white solid at −228 C. It is the highest performing oxidizer available, with the possible exception of ozone with some fuels. It does, however, have the drawbacks of being a cryogenic liquid, of being extremely corrosive, and of being quite toxic and forming toxic and corrosive combustion products.

Hazards

Tests on animals at low exposure levels showed that repeated daily inhalation (5.5 hr) of 2 ppm was highly toxic. Few toxic effects were observed at 0.5 ppm. The sharp odor, however, is sufficient warning of dangerous concentrations. Fluorine produces chemical-type burns on the skin similar to those produced by HF and may be treated as such.

Face shields, preferably of highly fluorinated transparent polymers, should be worn when near fluorine under pressure. Protective clothing and respirators are required, clean neoprene gloves should be worn, and safety glasses should have metal rather than plastic frames to avoid having the frames catch fire. Adequate ventilation and continuous inspection are extremely important.

Materials for Handling

Fluorine attacks practically all substances which are not completely fluorinated. Fortunately, the reaction with metals is slow at or below room temperatures, and in many cases results in the formation of a protective fluoride film.

Suitable tank materials are monel, stainless steel (18–8), and aluminum 61. Lines and fittings may be made of monel, copper, 18–8 stainless, or aluminum 17, 24, or 52; valve bodies of monel, bronze or 18–8 stainless; valve seats of copper or 2S aluminum; valve plugs of 18–8 stainless or monel; valve packing of Teflon; valve bellows of monel, bronze or 18–8 stainless; and gaskets of 2S aluminum or copper. All materials should be scrupulously cleaned and passivated.

Cost and Availability

Fluorine is currently available in tank truck quantities (5000 lb) at less than $4/lb. It is estimated that the price would drop to about $1.50/lb at a production rate of 20 million pounds per year.

Table 1 Physical Properties of F_2

Boiling Point	−188.14 C	−306.55 F
Freezing Point	−219.62 C	−363.32 F
Critical Temperature	−129.2 C	−200.6 F
Critical Pressure	55 atm	808 psia
Liquid Density at Boiling Point	1.51 g/cm^3	94.27 lb/ft^3
Viscosity at Boiling Point	0.257 centipoise	—
Vapor Pressure: $\log P(mm) = 7.08718 - \frac{357.258}{T} - \frac{1.3155 \times 10^{13}}{T^8}$		

Table 2 Chemical Properties of F_2

Heat of Formation (liquid) at Boiling Point	−2.874 kcal/mole
Heat of Vaporization at Boiling Point	1.564 kcal/mole
Heat of Fusion	0.1220 kcal/mole
Heat Capacity at Boiling Point	13.948 cal/mole C
Maximum Allowable Concentration in Air	0.5 ppm

Table 3 Theoretical Performance of F_2*

Fuel	Specific Impulse(sec) Frozen Flow	Specific Impulse(sec) Equilibrium Flow	Chamber Temperature** (Deg K)
N_2H_4	334	363	4675
NH_3	330	357	4542
H_2	398	410	3869
Li***	352	382	5500

* P_c = 1000 psia; P_e = 1 atm; optimum O/F ratio.

** Corresponds to equilibrium-flow impulse.

*** Figures estimated from 300-psia data.

CUT ALONG THIS LINE

Mail Bag

(CONTINUED FROM PAGE 16)

ciate your advising me if it is possible to obtain these back copies and the cost.

A. I. Sibila
Manager of Space Sciences
Chance Vought Aircraft
Dallas, Tex.

Thanks for the kind words about the two ARS publications. Copies of Astronautics *from January through September 1959 are on the way—Editor.*

Seek Reprints

Gentlemen:

The Military Traffic Management Agency is considering preparation of an information manual dealing with methods and materials of missile propulsion. The purpose of this publication will be to familiarize transportation personnel more fully with the characteristics of such commodities. It would be used for educational and reference purposes within the military services. . .

Among the articles selected for republication, if the requisite authority is granted, are the following from *Astronautics:* 1. Ramjet Fuels: A Brief Survey, September 1958. 2. Cold Propellants for Hot Performance, September 1958. 3. Liquid Rockets, November 1958.

If you are agreeable to the use of this material as set forth above, it will be appreciated if you will furnish this Agency a letter authorizing such reproduction.

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Lt. Colonel, TC
Director of Traffic for Missiles
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Washington 25, D.C.

As part of our communication program, we furnish to military and civilian executives of our agency reprints of thought-provoking and challenging editorials and articles. We have found "Sociology and the Space Age" by Jiri Nehnevajsa in your September 1959 issue of *Astronautics* to be in this category.

We would like to obtain your permission to reprint this article. Distribution will be limited to some 250 executives for internal use only.

RICHARD B. PRATT
Communication Assistant
Army Ballistic Missile Agency
U.S. Army Ordnance Missile Command

The Thermodynamics Department of the U.S. Air Force Academy is preparing a set of lecture notes for the use of students in the applied thermodynamics phase of our course. In searching for an appropriate faceplate subject, the cover photograph of the June 1958 issue of *Astronautics* appears to be just what we need. Therefore, we request permission to use it with, of course, appropriate credit. . .

GEORGE F. BABITS
Lt. Colonel, USAF
Assistant Professor of Thermodynamics
Department of Thermodynamics
U.S. Air Force Academy, Colorado

Permission for use of material from ASTRO *has been granted in all the above cases, and thanks for the kind words about our publication.—Editor.* ♦♦

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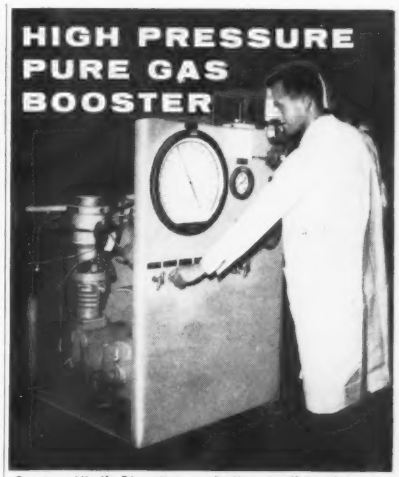

Courtesy Missile Div., Minneapolis-Honeywell Regulator Co.

Completely integrated, portable, high pressure non-contaminating gas compression system. A diaphragm compressor boosts cylinder pressures of 500-2,000 p.s.i. to 10,000 p.s.i.g. System also includes a 0.5 cubic foot accumulator, valves, fittings, gauges, etc., together with space for two manifolded gas cylinders on heavy steel panel mounted on casters.

Write for Bulletin 7 C.

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From the patent office

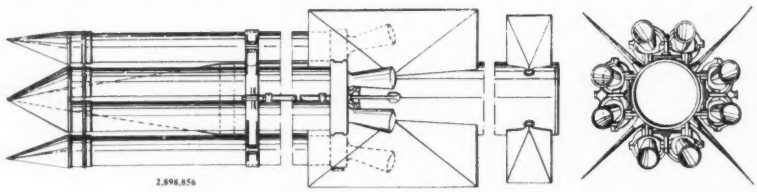
By George F. McLaughlin

Individual Nose Cones Cover Multiple Booster Motors

Assigned to Sir W. G. Armstrong, Whitworth Aircraft, Ltd., England, this patent relates to missiles having discardable "wrapped-around" booster motors, which provide initial acceleration and are then discarded, as in the Bloodhound missile.

Object of the invention is to improve the arrangement of such booster motors aerodynamically. Motors are symmetrically arranged around the missile in pairs. Their forward ends are secured to the missile just aft of the tapered front part of the missile, and their after ends are also secured to the missile body.

The forward ends of booster motors are cones with axes diverging from the axis of the missile at an angle slightly greater than the design angle of yaw of the missile during boosted flight. When applying the invention to a missile in which the booster motors are arranged in groups of two or more, motors of each group share a common nose. In plan, the pointed extremity of the nose lies central to the motors of the group. In side elevation, the nose extremity of each group points outward.



Side and front views of discardable booster motors.

Patent No. 2,898,856. Self-Projected Missiles. Alexander Lightbody and James Morrison Johnson, Coventry, England.

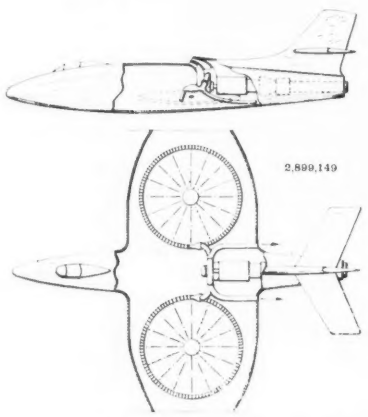
Vertical-Climbing Jet Aircraft

One of the most versatile and prolific pioneers in producing original types of aircraft was the world famous French engineer and pilot, Louis Breguet. The range of his novel inventions included one of the first successful helicopters and many unique and daring concepts in military and commercial aircraft. Until his death in 1955, he was active head of the organization bearing his name. In 1953, he had invented a turbine-driven ducted-fan aircraft, for which device a patent was recently granted.

Several variations of the design are possible. The two lift rotors in the wing may be directly driven by gas or compressed air and a portion of the flow diverted to drive conventional propellers installed on shafts ahead of the wing. In another version, the rotors can be turbine-driven and forward thrust supplied by direct conventional jet, as shown in the accompanying illustration.

A separate compressor absorbs a large portion of the available engine power. Compressor air is utilized by expansions to supply a reactive thrust which is added to the normal propulsive effort. By providing burners ignited momentarily or continuously in this air flow for taking off or gaining speed peaks, an increase in the kinetic energy is obtained.

Each lift rotor consists of narrow vanes actuated by power applied at the periphery of an outer ring. Direct utilization of the jet on the blades at high ejection speeds (800 meters per second when using an aftercombustion device) enables full utilization of the increase in power.



Versions of turbine-driven ducted-fan aircraft.

Since injection occurs only on a small sector of the wing, the blades are subjected to contact with high-temperature gas only briefly during each revolution. Therefore, the air temperature in the combustion chambers can be raised without excessive heating of the rotor.

Upper and lower surfaces of the wing may have automatic or controlled louvres that can be opened during hovering to allow the ambient air to pass vertically through the rotor. During horizontal travel, the louvres would be closed to ensure correct profile, permitting the highest speeds. The louvres could also be used to vary the centre of lift of the rotors and to ensure equilibrium of the aircraft at low speeds.

The supporting surface of the wing can normally provide the lift of the aircraft during horizontal travel. The lift rotors would be used only during part of the flight, for example, for vertical climbing, hovering, or landing. During hovering, controls are activated by directing part of the compressed air to the tail unit.

Patent No. 2,899,149. Aircraft Having Ducted Turbine-Driven Lift Rotors. Louis Breguet (deceased), Paris, France.

Dual-Range Rocket Projectile

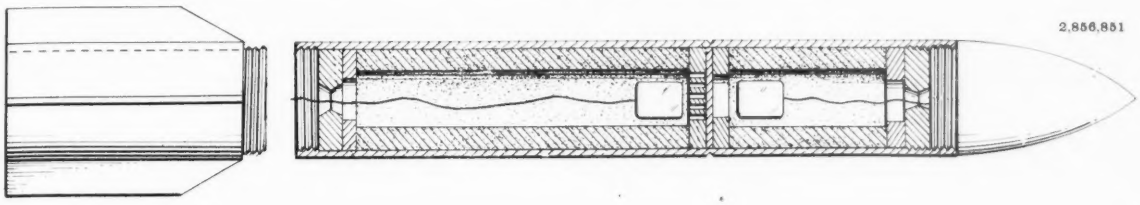
A dual-charge solid propellant rocket will give either of two ranges provided there is some means of selectively burning one or both of the charges. The invention, illustrated in concept below, offers a way to do this.

The propulsion system consists of two solid motors separated by a "zoning wall" and terminating at either end in nozzles. The zoning wall consists of a burst diaphragm held against a perforated plate which can sustain pressure from one motor but not from the other, that is, the one directing pressure against the unsupported face of the diaphragm.

Both motors have igniters, either of which can be fired alone. For short range, the motor directed against the supported face of the diaphragm would be fired. For long range, the motor directed against the unsupported face would be fired, subsequently bursting the diaphragm and propagating an igniting flame into the second motor. The position of the head and fins can of course be reversed, depending on whether single- or dual-charge operation is wanted.

A rocket of this kind might be adapted quickly in the field as an antitank or antipersonnel weapon.

Patent 2,856,851. Apparatus for Zoning Rockets. Harold E. Thomas, Alexandria, Va., assignor to the U.S. Army.



Noise-Exposure Meter

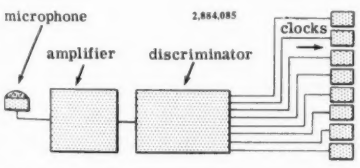
Total time that noise exceeds predetermined levels can be read directly from a small portable meter which makes it possible to follow accumulation of noise over long periods of time.

In this invention, a transducer converts noise to an electrical signal. When it exceeds a certain level, the amplified signal produces outputs indicating the total time the signal is above that level. The meter gives intensity versus time information, and allows monitoring of noise exposure of man, animals, and equipment.

The device consists generally of a microphone, a two- or three-stage amplifier, an intensity discriminator, and a group of clocks. The discriminator consists of n electromagnetic relays connected to the output of the amplifier, when n is equal to the number of intensity levels for which intensity versus time information is desired. Relays are adjusted so that the first one is energized when the output current exceeds a value i_1 which is proportional to the noise level for which a first reading is desired. The second relay is energized when the output exceeds a value of i_2; etc.

By using miniature tubes or transistors, pocketsize models of the exposure meter can be made. The instrument will show the total time personnel are exposed to different noise intensities connected with specific jobs, thereby helping to achieve safer operation and greater efficiency.

Patent No. 2,884,085.. Noise Exposure Meter. Wolf-Wito von Wittern, Karlsruhe, Germany, and Henning E. von Gierke, Medway, Ohio, assignors to the U.S. Air Force.



Block Diagram of Portable Noise-Exposure Meter.

Aluminum Alloy for Liquid Rockets

North American Aviation has been granted a patent on its Tens-50 aluminum alloy, which is now being used extensively in castings for many large liquid-propellant rocket engines. A small amount of beryllium in the alloy prevents its embrittlement by iron impurities picked up in the casting process. NAA developed Tens-50 to avoid the conventional "high-purity" approach to high-strength aluminum castings. The cast Tens-50 goes well into the strength area of forgings.

Better Electrical Standards

The National Bureau of Standards is working on a new realization of the ohm and plans a new realization of the volt—the two basic units in deriving electrical standards.

A Little Boost for Dynasoar

Designed by Curtiss-Wright's Santa Barbara Div. for maximum performance at low altitude, this three-stage solid-propellant rocket, the HVT-2, reaches a velocity of Mach 10 within 10 sec after ground launching. It has been used at Holloman AFB to boost scale models of the Dynasoar flight capsule in studies of aerodynamics and heating. Curtiss-Wright developed the rocket over the past two years under Air Force and Boeing sponsorship.

The Visicorder records

Unretouched Honeywell Visicorder record, actual size.

This study of the drop in voltage load on an Allis-Chalmers alternating current generator was directly recorded by a Model 906 Honeywell Visicorder.

In this transient reactance test, made by design engineers at the Allis-Chalmers Norwood Works, the generator was operated at full voltage, and then a dead short was applied to the terminals. When such a sudden load is thrown upon a generator, the voltage drops because of the inherent characteristics of the generator. This voltage "nosedive" is so rapid that a voltage regulator cannot immediately correct the voltage and bring it up to normal. Because of this time delay while the regulator is catching up, motor contacts and other devices on the line may drop out, lights may blink objectionably, and electronic devices may function erratically. For these reasons, these studies of time as related to generator characteristics are very important to better generator design. The Visicorder's ease of operation, calibration, and immediate readout made it ideal for these studies.

N. O. Risch and F. R. Manning, design engineers at Allis-Chalmers Norwood Works, study a Visicorder chart of voltage-drop tests on a generator.

ds generator voltage load-drop

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

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Reference Data: write for Bulletins 1108, 1012, and HC906B.

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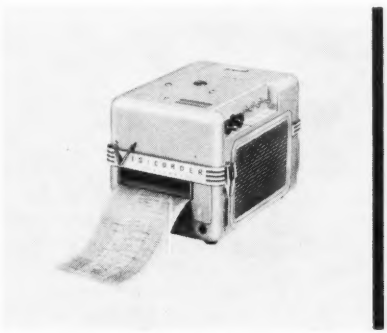
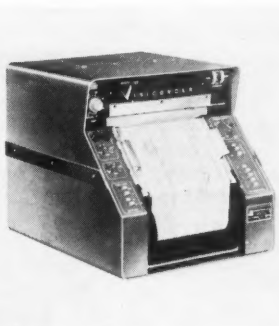
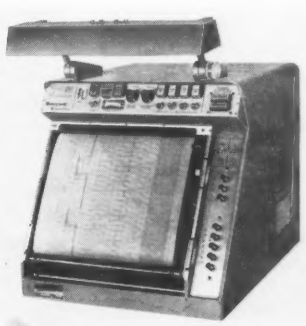


Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 24 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

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Capable of handling units 35 ft long, 7 ft in diam, and 40 tons in weight, this mobile Transrector, developed by Siegler Corp.'s Hufford Div. for Thiokol, will be used to carry solid-propellant rocket motors to test areas and to place them precisely in a horizontal or vertical position in a static-testing stand.

Role of Simulators

(CONTINUED FROM PAGE 39)

exact functions of a spacecrew holding facility. We are assuming that a holding facility consists of all the equipment, facilities, and personnel required to assemble, check, adjust, hold in a state of readiness and, at the appropriate time, prepare and launch a space vehicle. We are assuming that the crew is an integral part of the system and that the holding facility is expected to perform operations analogous to those listed above with respect to the spacecrew. Just as it is assumed that the space vehicle will have been designed and developed at some location other than the holding facility, we are assuming that the crew (or crews) will have been selected and will have undergone extensive training and indoctrination at various locations prior to assignment to the holding facility. As a matter of convenience, it is assumed that the duration of residence at the holding facility will average from two to four months.

A specific stipulation which we would like to make is that intensive, rigorous, thorough training is vitally important for space-vehicle crews and that concern with the performance capabilities of crewmen must continue up to the moment of launch and indeed beyond. Logically, in view of our experience with modern weapon systems, there should be no need to defend this statement. However, the problem of training has not received sufficient emphasis in thinking and planning for manned spaceflight.

There are at least three reasons why this has been true. First, in the human-factors field, most effort has been devoted to *protecting* man in space. Obviously, personnel protection is an important and absolutely basic problem. Its solution, however, represents only a partial answer to the human-factor problems involved in the design and use of an effective manned space-vehicle system. Equal in importance to the protection issue is the problem of assuring the development and maintenance of the required human *performance capability.*

Secondly, there has been a false assumption that man will have very little of importance to do in space. We have already discussed this point in some detail.

Thirdly, there has been a feeling on the part of many people that spacecrews, at least the early ones, will be so highly selected, so experienced, and so adaptable that they really won't need to be trained in the usual sense of the word. This to us makes no more sense than saying that a high-speed computer does not need to be reprogramed for a new problem simply because it is well designed, has the capacity to accomplish the new problem, and has a history of past successes on related problems. We feel, and our paper is based on this stipulation, that training is of great importance even for highly selected spacecrew members.

Granting these assumptions and stipulations, let us examine some of the important roles which might be fulfilled by simulators at a spacecrew holding facility.

Several Simulators

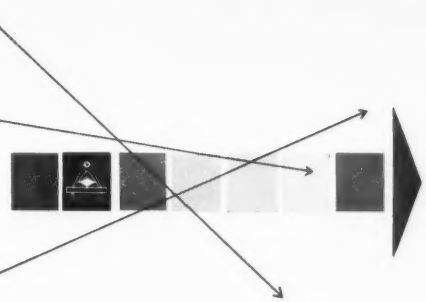
There probably will be several devices at the holding facility which will qualify as training simulators. The major differences among these will be in terms of the number and type of operational task conditions which they include and the degree to which these are simulated. For example, the primary device, and the one which will receive greatest emphasis during holding, will be a high-fidelity ground-based simulator with a "full mission" capability. This device will permit realistic practice of virtually all of the relevant tasks and task conditions likely to be encountered during the course of a complete mission from prelaunch to recovery. In addition, there probably will be several partial-mission training devices, or subsystem simulators, which can be used for more extensive practice on selected tasks and elements of the mission.

We are not concerned here with the specific design details nor the logistical considerations of the over-all training system. These will be determined by the particular characteristics of the vehicle and mission to be simulated and by the particular training strategy employed. Rather, our emphasis is directed toward some of the general functions which simulators might serve during the holding phase. It will be apparent later that the functions discussed below are not mutually exclusive, nor for that matter all-inclusive.

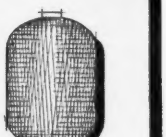
Maintaining Proficiency and Performance Peaking. As was mentioned previously, it is assumed that all system personnel will have had considerable training prior to initiation of the holding phase. However, it is imperative that continuing practice be given not only to maintain the requisite performance within acceptable tolerances, but also to achieve that added integration and "peaking" of behaviors which will increase the probability of mission success and personnel survival.

There is considerable evidence, both empirical and anecdotal, which attests to the value of continuing practice beyond the point where performance appears to level out. One of the obvious benefits of such overlearning is that it improves retention. Another advantage, not quite so obvious, is that it effectively increases man's channel

Garlock's main objective



in missiles work . . .



Filament wound rocket motor cases made by exclusive Garlock method result in structure much lighter and stronger than steel.

Insulation for solid fuel rocket motors made by Garlock is rubber-like compound which encounters gas velocities of Mach 3-5, temperatures to 5500° F., prolonged ambient temperatures of 300° F.

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Garlock metal fittings for rocket motor cases such as blast tube and thrust terminator support rings are machined to extremely close tolerances. Made from special materials affording minimum weight, maximum strength and rigidity.

is delivery of high quality rocket motor components in the shortest time. To reach this common goal, research and development, product design, tool design, pilot manufacturing, and production staffs work together as a fully integrated team. They solve problems of design and production jointly, thus eliminating weeks of possible re-designing and re-tooling.

Garlock is flexible: they'll swing into prototype production on short notice and follow this with full scale production as needed. *Garlock is diversified:* they'll design and manufacture rocket motor components from a variety of basic materials—rubber, metals, phenolics, fluorocarbon plastics.

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capacity by promoting the virtual automatization of many kinds of behavioral skills. This automaticity is extremely important in the case of critical tasks which must be time-shared with other activities or performed with high reliability under conditions which tend to disrupt learned behavior.

Inter-Crew Training

In conventional flight systems, the training emphasis is frequently directed toward flight crews to the relative exclusion of ground personnel. Such an approach to the training of space-system personnel would be disastrous. It is essential that both flight and ground-control personnel be welded into an efficient, integrated team. The performance of ground personnel and the interaction of ground and flight crews has a much more direct effect upon mission success than in previous manned flight systems. Therefore, in peaking system performance, special attention should be devoted to those phases of the mission where the performance of one team element affects the state of the other, as in ground-initiated launch, emergency escape, re-entry, etc. Particular emphasis should be placed on working through joint exercises when communication links are faulty. One technique for promoting coordinated team action, and an appreciation of the system, is cross-training. In those systems where standby flight crews perform critical ground-control functions, cross-training will be effected as a matter of course. Where this is not the case, it may have to be introduced as an "extra-curricular" activity.

System Checkout and Final Crew Selection. It is extremely important that the simulator facilities provide the capability for observing and evaluating all relevant aspects of personnel performance. This is necessary, of course, for identifying performance deficiencies and prescribing remedial action during training. However, it also is required for assessing the operational readiness of the system, and provides a basis for the final selection of the operational crew from among the available candidates. It seems entirely reasonable that the performance readiness of candidates should be an important factor in designating the crew to be used and in assessing the operational readiness of the system at any time.

Mission Briefing. Actually, it is unlikely that there will be any drastic revisions in the profile of a proposed space mission immediately preceding launch. However, the simulator might be used for briefing with respect to the selection of procedural options or other last minute information and conditions which might have significance for system performance. Of course, much of the experience that crews will receive in the course of normal training can be regarded as briefing, since practice missions undoubtedly will be continually updated to reflect the latest information concerning anticipated vehicle and mission characteristics. With this in mind, it is easy to see the importance of a highly flexible mission simulator in providing this opportunity for up-to-date experience.

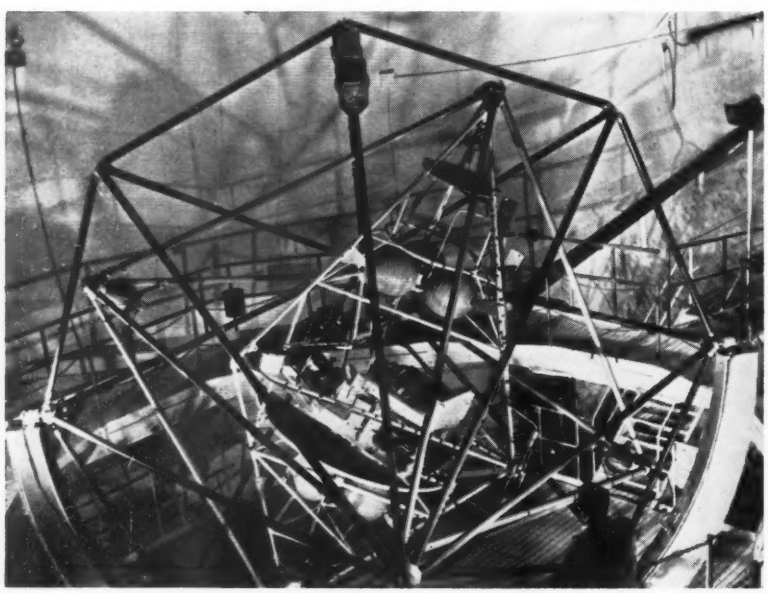
Establishment of SOP's. Superimposed on the various functions discussed previously, the simulated situation can provide a realistic performance context for the origination and refinement of standard operating procedures. This would be particularly important in the case of long-term missions in systems with multiple crews. In such cases, it would be highly desirable for crew members to develop working routines and to be completely adapted to an efficient work-rest cycle prior to launch.

Handling Emergencies

The importance of well-established SOP's in the handling of emergency situations has long been recognized. With the increased time pressure and decreased margin for error, they will be even more important in space systems. In addition, on long space missions, firmly established crew routines and work-rest cycles will increase individual efficiency and harmony among crew members. Recent studies indicate that the role of the simulator in this area should not be underestimated.

Prelaunch Warmup. Since in some instances crew members may spend several hours in the flight vehicle prior to launch, it would seem highly desirable to provide an opportunity to rehearse and warmup critical procedures which may be required during and shortly after launch. Here, again, there is considerable empirical and anecdotal evidence which indicates the value of such procedures. This briefing and warm-up could be accomplished by feeding simulated signals into the flight vehicle while holding on the pad. For, even with very highly trained personnel, this last minute checkout could provide one additional bit of insurance for mission success.

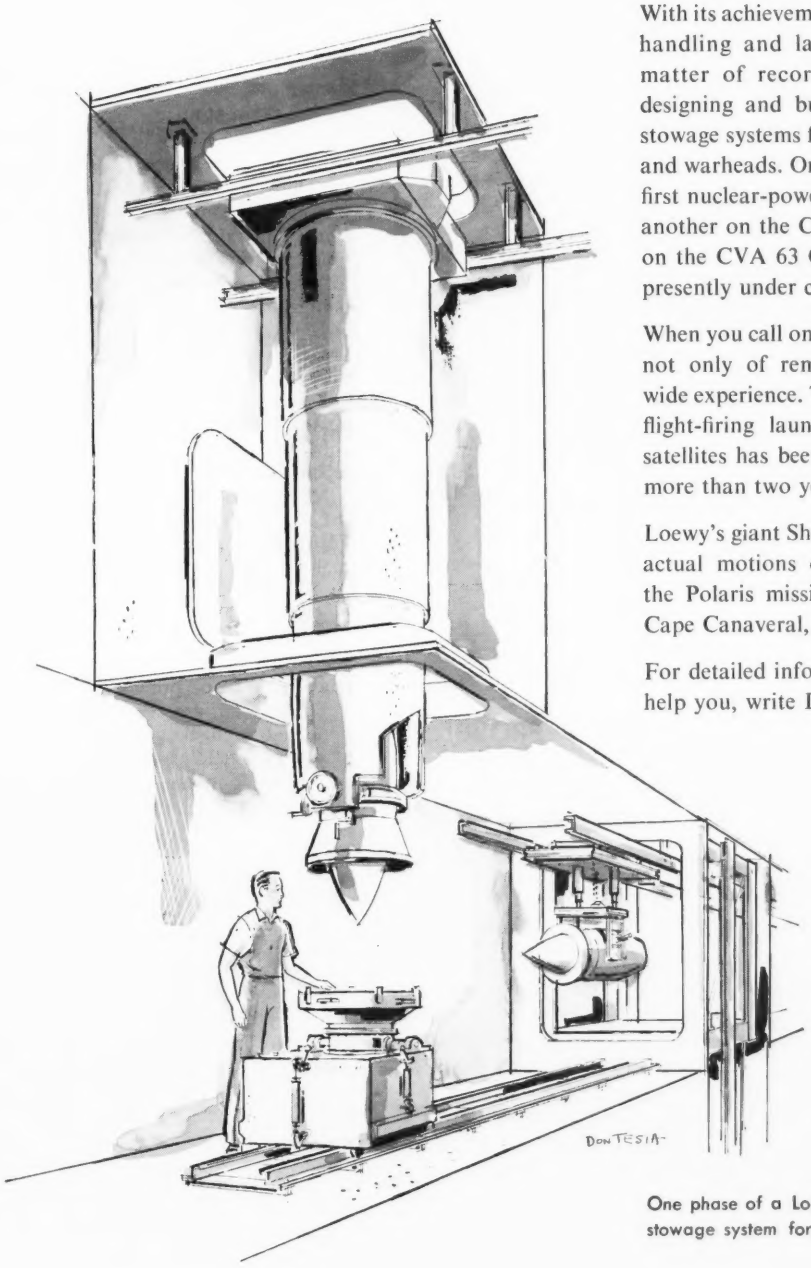
Although somewhat beyond the scope implied by the title of this paper, the problem of maintaining crew proficiency after launch is sufficiently important to warrant brief consideration. Long-duration missions, such as those involving interplanetary travel



Training for a Space Spin

This machine at NASA's Lewis Research Center, Cleveland, Ohio, spins its occupant, strapped at the center in a contour couch, at up to 50 rpm in any direction. The seven Project Mercury Astronauts will train in the device.

For Terrier and Talos missiles and warheads . . . new shipboard handling and stowage systems by Loewy



One phase of a Loewy handling, mating and stowage system for warheads on shipboard.

With its achievements in missile and rocket ground handling and launching equipment already a matter of record, Loewy-Hydropress is now designing and building shipboard handling and stowage systems for the Terrier and Talos missiles and warheads. One system is to be installed on the first nuclear-powered cruiser, U.S.S. *Long Beach;* another on the CG 10 Class cruisers; and a third on the CVA 63 Class aircraft carriers, which are presently under construction.

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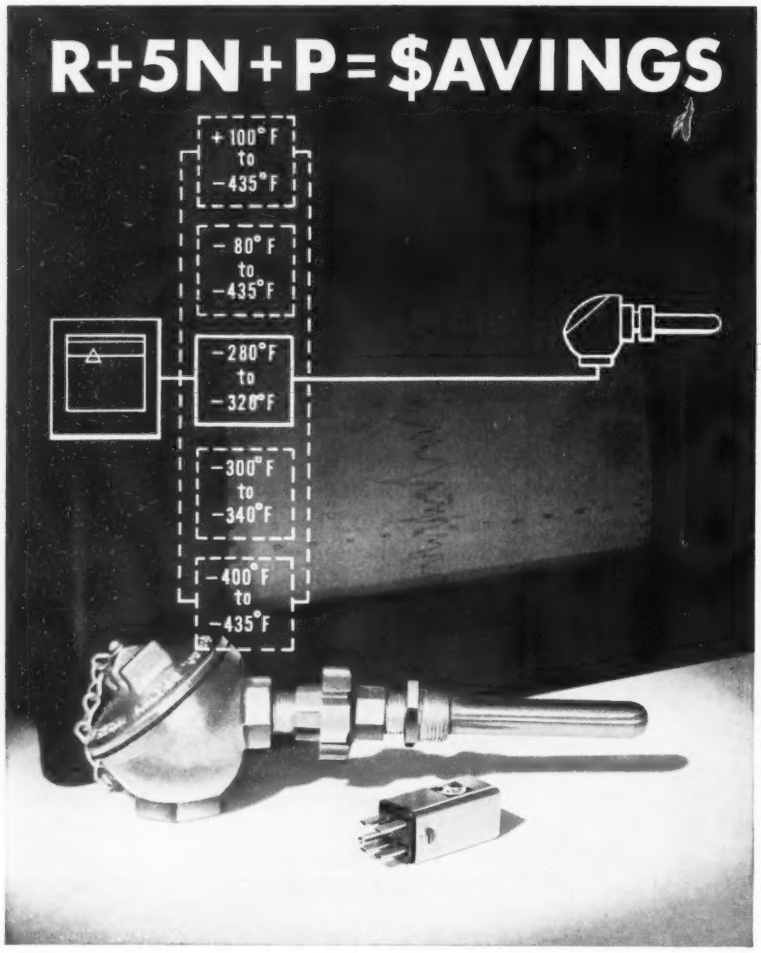

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or extended orbital flight, could present some serious problems with respect to the maintenance of little used but critical behaviors. For instance, according to present calculations, it would be several months from launch until a manually controlled soft landing on Mars could be effected. In the interim, there would be no opportunity for on-the-job practice. Thus, this extremely critical maneuver would have to be performed without even the benefit of a warmup.

Maintaining Skills

Two approaches to the problem of maintaining performance during long periods of operational disuse are: (1) Provide job aids which can be used to guide performance when required and (2) provide an on-board training capability so that skills can be exercised on route. Obviously the job-aid approach is most appropriate for procedural tasks with high information content but low perceptual-motor skill demands. A large number of tasks involving troubleshooting, assembly, and repair, etc. fall into this category.

Many tasks, on the other hand, are not so amenable to symbolic storage. For instance, continuous-control tasks, such as might be required in the Mars landing operation, must be exercised to be maintained at peak efficiency. For tasks of this nature, then, a simulated training or exercising capability might have to be provided.

These, then, are some of the functions that might be performed by simulators at a holding facility. Each of these functions could and should be discussed much more thoroughly. Our purpose here has been mainly to identify them.

One important point remains to be mentioned, and that concerns the planning of spacecrew training facilities. Spacecrew training facilities need to be planned and designed along with and as an integral part of a space-vehicle system. Their planning cannot be left to chance any more than can the planning of ground-support equipment. Furthermore, the steps involved in the design of a training facility are as logical and as system-oriented as the design of the vehicle itself, and permit of no great margin for error.

Too often, in our thinking regarding spaceflight, training problems have been left to be considered "later." We will not be putting our best foot forward in the conquest of space until we program and plan for the development of the required human skills in an integrated and system-oriented manner. ♦♦

Life & Physical Scientists; M.D.'s

Republic Aviation Accelerates and Expands Its Space Environment and Life Sciences Research Under Direction of Dr. Norman Lee Barr

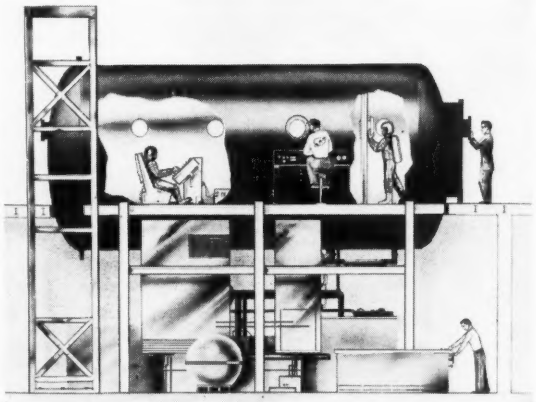
(Captain, USN, ret.)

A Number of New Positions for Research Supervisors and Participating Scientists Now Available on Space/Human Factors Problems

Dr. Barr is one of the few scientists in the country who has conducted live experiments under actual space flight and re-entry conditions. (Dr. Barr directed the Navy project which launched monkeys Able and Baker on their successful 1500 mile trip through space at an altitude of 300 miles.)

As Chief of Republic's Space Environment and Life Sciences Laboratory, Dr. Barr will direct research into all aspects of space environments, artificial and natural, and the problems of adapting these environments to the support of human life and its function. With the opening of Republic's new $14,000,000 R&D Center (scheduled for late spring), current programs will be expanded and new programs initiated.

Formerly Director of Aviation and Space Medicine Research for the U.S. Navy, Dr. Barr joined Republic as Chief of Space Environment and Life Sciences Research in November 1959.



Rendering of the space chamber which will be part of the research facilities of the Space Environment and Life Sciences Laboratory in the new Center. This chamber will be capable of taking a human being 150 miles up into simulated ionospheric conditions. In the test shown above, peripheral vision and mobility of the space-suited man is measured, as he responds to various test sequences set up by engineers at outer control panel.

Research programs in which M.D.'s (high altitude experience preferred) and other scientists may engage include:

- **Studies in low-pressure plant growth for lunar base applications**
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- **Conversion of human wastes into food, water, and support for man and new plant life in a continuing cycle**
- **Control of disease agents in a space vehicle**
- **Investigations of the physiological and psychological reactions of man under ionospheric conditions**

Scientists and M.D.'s who share Republic's conviction of the urgent need to develop a self-sufficient, closed, environmental system capable of maintaining an astronaut in a state of essential physical health and efficiency, are invited to write to Dr. Norman Lee Barr.

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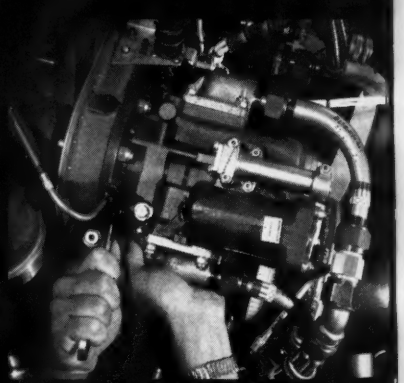

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People in the news

APPOINTMENTS

NASA has announced that its Office of Aeronautical and Space Research will henceforth be known as the Office of Advanced Research Programs and be under the direction of **Ira H. Abbott,** and the Office of Space Flight Development as the Office of Space Flight Programs under the direction of **Abe Silverstein.** The space agency has also set up a new Office of Launch Vehicle Programs to be headed by **AF Maj. Gen. Don R. Ostrander.**

Harold W. Ritchey, current vice-president of the AMERICAN ROCKET SOCIETY, has been promoted from vice-president and technical director to vice-president in charge of rocket divisions of Thiokol Chemical Corp. **Joseph C. Jorczak** has also been appointed a vice-president. Named to Dr. Ritchey's staff are **E. F. Nauman** as general manager, Utah Production Div., and **Bryce Wilhite, H. Q. Holley,** and **John Womble. Ray McElvogue** succeeds Nauman as general manager, Longhorn Div.

Frederick C. Durant III, past president of ARS, has been named director of public and government relations at Avco's Research and Advanced Development Div.

Eugene B. Konecci has been appointed chief of the new A-260 life sciences section at Douglas Aircraft. **D. J. Davis** becomes assistant chief in the advance design section-missile systems; **Edward F. Spraitz,** assistant Washington representative for space programs. Other appointments include **R. V. Keeler** and **A. C. Robertson** as supervisors in advance design-missile systems and space systems, respectively.

Donald F. Spencer has joined the staff of James M. Bridges, DOD's Director of Electronics. Spencer was formerly head of the Navy's BuAer AS Missile Guidance Unit and avionics system engineer on Bullpup.

Augustus B. Kinzel, vice-president for research of Union Carbide Corp., has been appointed chairman of NAS-NRC's division of engineering and industrial research.

At GE's Missile and Space Vehicles Dept., **Jack Katzen** has been appointed manager of engineering administration and integration, while **Otto Klima** has been named manager of a systems engineering operation.

Allan G. Norem, former chief of the Structures Div. of Aerophysics Development Corp., has joined the technical staff of ARPA, where he will work in the areas of space technology and materials research.

Robert R. Goldsborough has been appointed manager of the AN/ASD-1 program for development and design of airborne electronic equipment at Sylvania's Electronic Systems Div.; **Robert L. Amelang,** administrative staff supervisor; **Rudolph Cazanjian,** quality assurance supervisor; and **Melbourne J. Myers,** technical manager for the program.

Coleman duP. Donaldson has been elected president and a board member of newly incorporated Aeronautical Research Associates of Princeton, Inc.

Beckman Instruments has appointed **Leland G. Cole** vice-president, research.

Herman H. Waggershauser has been elected a vice-president at Eastman Kodak and has also been appointed general manager of the Apparatus and Optical Div.

Raymond R. Bouche becomes manager of the Standards and Analysis Dept. at Endevco Corp., Pasadena, Calif.

Edward L. Montgomery has been appointed executive assistant to the vice-president and general manager of Aeronutronic. **S. Dean Wanlass** becomes manager of Product Planning, a new post.

M. John Rice Jr. has been appointed manager of semiconductor material engineering for CBS Electronics, manufacturing division of Columbia Broadcasting System. **A. H. Andrews** joins the division as an engineering specialist.

Robert B. Corby has been appointed staff engineer in the Program Planning Dept. of Motorola's Western Military Electronics Center.

Donald C. Beem has been named senior design engineer in charge of design and development of solid state power supplies, special products group, Spectrol Electronics Corp.

Vadim N. Martinovitch has joined Stavid Engineering, Inc., as consultant in high power modulator and radar systems design.

Martin Dubilier has been named general manager of ITT's International Electric Corp.

Frank Collamore has been named chief development engineer in charge of a new power equipment development program for Leach Corp.'s Inet Div.

Henry Abajian, vice-president of Intercontinental Electronics Corp., will be in charge of the Engineering Dept., a consolidation of engineering and manufacturing activities.

M. Lloyd Jones Jr. has been advanced to general manager of Aeroquip's General Logistics Div.

R. L. Garman has been named corporate vice-president, engineering and research, of the newly formed General Precision, Inc., a subsidiary of General Precision Equipment Corp.

Stanley Fried, applications engineer

Ritchey

Durant

Konecci

Cole

Bouche

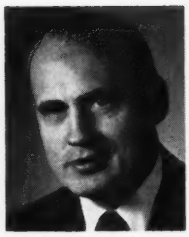
Abajian

Fisher

Metsger

Oppenheim

Benton



Nelles

Vogel

at Yardney Electric Corp., has been elected president of the Government Contract Management Assn. of America, Inc.

James H. Fisher will head the newly formed advanced technical planning group at Electro-Optical Systems, Inc., while continuing as manager of the Energy Research and Advanced Power Systems Div. **Glenn Cate,** former advanced systems designer, Douglas Aircraft Missile and Space Engineering Dept., has joined the company as senior engineer in the Space Defense Systems Div.

Rear Adm. A. B. Metsger, (USN-Ret.), has been appointed assistant to the president of Marquardt Corp. to assist in planning and coordinating the company's technical efforts.

Joseph Oppenheim has been named programs manager for Raytheon's Missile Systems Div. and will manage all divisional programs including the areas of engineering production, flight test, field services, and finance.

Charles Benton Jr. has been promoted from divisional general manager to president of IBM's Federal Systems Div.

Hoffman Electronics Corp. has announced the appointment of **Lloyd T. DeVore** as director of engineering of the Laboratories Div., and of **Henry F. Schoemehl** as director of engineering at its semiconductor plant in Evanston, Ill.

Maurice Nelles has joined American Electronics, Inc., in the newly created post of vice-president, engineering.

McDonald

Criddle

Hugo Woerdemann, president of Magnetic Research Corp., Hawthorne, Calif., has assumed the additional post of director of engineering.

Dorothy P. Vogel has been elected vice-president and general manager of Colvin Laboratories, Inc., electronics and avionics firm in East Orange, N.J.

Erwin O. A. Naumann has been upped from chief of advanced studies, Solar Aircraft Co., to manager of development in the research and development engineering division.

Raymond W. Wells, former chief electronics engineer, Aircraft Armaments, Inc., has been promoted to director of engineering.

Allegany Instrument Co. has appoined **Alfred Schaff Jr.** as executive vice-president and general manager.

Lawrence S. Churchill Jr. has joined Stavid Engineering, Inc., as engineering consultant in underwater electromagnetic propagation and ASW projects.

Albert A. Canfield has been appointed director of university and scientific relations, Bendix Aviation Corp.

Philip S. Hessinger has been named manager of research of National Beryllia Corp., North Bergen, N.J.

Earl A. Weilmuenster, former director of fuels research of the Energy Div., Olin Mathieson Chemical Corp., will direct activities at the new rocket fuel research laboratory of United Research Corp. of Menlo Park.

Robert W. Cairns, director of research, Hercules Powder Co., has been elected a board member.

G. W. Rutherford, manager of Ryan Electronics Div. of Ryan Aeronautical, has been named a vice-president of the parent company.

William C. Leone has been named vice-president and general manager of Rheem Califone Corp., subsidiary of Rheem Mfg. Co.

John J. McDonald and **Linden G. Criddle** have been elected vice-presidents of Consolidated Systems Corp., subsidiary of Consolidated Electrodynamics Corp. McDonald and Criddle will continue as directors of engineering and operation, respectively. **Arthur O. Wolf** has been appointed manager of Spectron, a department of CEC's Transducer Div.

At Hughes Aircraft, **David A. Hill** has been made manager of the Semiconductor Div. of the Hughes Products Group; **Lloyd H. Scott,** manager of the Santa Barbara Research Center; and **L. James Levisee,** director of material, general office. **Norman A. Baily** has joined Hughes' nuclear electronics laboratory as senior staff physicist.

Robert F. Goodwin, vice-president of Airtek Dynamics, Inc., Los Angeles, has been elected president.

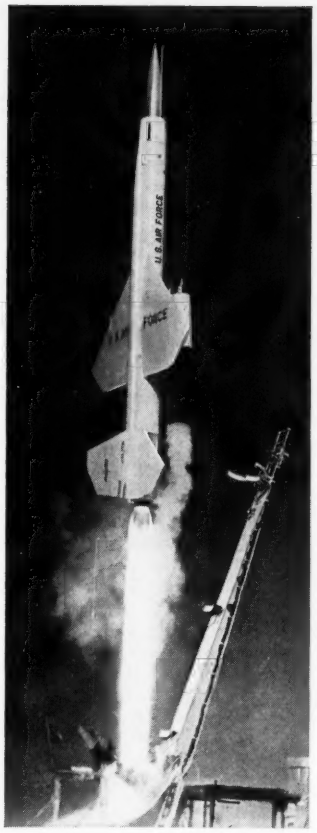
Carlo V. Bocciarelli has been appointed associate director of Philco's Research Div. in charge of the Basic Science and Technology Dept. **William H. Forster,** former director, Research-Solid State Electronics, has been transferred to Philco International Corp. for a special research assignment in Europe.

Frank B. Jewett Jr., executive vice-president, has been elected president of Vitro Corp. of America.

John W. Smith has joined the Ordnance Div. of Minneapolis-Honeywell Regulator Co. as assistant to **Clyde A. Parton,** vice-president and general manager of the division. ♦♦

R&D Men in Industry

The National Science Foundation estimates that U.S. business firms employed about 750,000 scientists and engineers in 1959 and that government and other agencies employed about one-third that number in addition. NSF plans to issue a report on the survey. An estimate from the research symposium held last summer in New York was that about 25,000 scientists in the country were engaged in "pure" research.



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ASTRONAUTICS Data Sheet — *Materials*

Compiled by C. P. King

Materials and Process Section
Marquardt Co., Van Nuys, Calif.

WROUGHT Cr-Mo-V DIE STEELS

For more than 25 yr, a group of proprietary materials has been used for tool and die work where the necessary requirements were high hardness and the ability to resist softening from exposure to 1000 F. Recently, similar requirements in high-speed aircraft and missiles have focused attention on these materials, which are now being produced in all-wrought forms with these advantages: (1) Very high strength and strength-to-weight ratio up to 1000 F; (2) good formability; and (3) high strength developed by air quenching, thus minimizing heat-treat distortion.

The Cr-Mo-V die steels comprise three types, designated H-11, H-12, and H-13 by the AISI. Many small changes have been introduced into the chemical composition of these alloys, but they conform very closely to the ranges shown.

Physical Properties

A typical Cr-Mo-V die steel has a density of 0.280 lb/in.^{3} and coefficient of thermal expansion (unit, 10^{-6} in./in./F) of 6.5 between 80 and 400 F, 7.1 between 80 and 800 F, and 7.4 between 80 and 1200 F.

Heat Treatment

These steels are preheated to 1400–1500 F and hardened at 1800–1900 F. Exact conditions vary with steel type. All three are air-quenched and tempered at 1000–1100 F; H-12 can also be oil-quenched.

Fabrication

Conventional techniques of sheet metal forming may be used on the Cr-Mo-V die steels in the annealed condition. Machinability is good in the annealed state but grinding is the most practical method of metal removal after hardening.

Joining

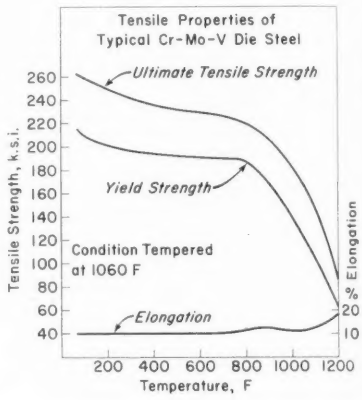
Preheating, post-heating, and stress relieving are necessary when welding the die steels. With these precautions, they can be welded satisfactorily. Welds are ductile, have a high joint efficiency and show less tendency to cracking than low-alloy steels.

Applications

The Cr-Mo-V die steels have found wide application in parts such as pressure vessels, turbine wheels, engine mounts, hooks, gears, springs, and fasteners. Bars, forgings, extrusions, sheet, and plate may be obtained in these steels.

Corrosion Protection

The Cr-Mo-V die steels do not possess enough resistance to corrosion to be used even in atmospheric exposure without protection. Plating of nickel, chromium, silver, cadmium, and diffused nickel-cadmium may be employed; but in order to avoid hydrogen embrittlement, stress relieving after plating is necessary. Vacuum deposition of protective metals is an acceptable alternative. Ceramic coatings, enamels, aluminizing, and silicone resins are also being used.



Effect of Tempering Temperature on Room-Temperature Properties of Typical Cr-Mo-V Die Steel

Tempering Temperature, F	Hardness Rockwell, C	UTS, psi	YS, psi	Elongation, %	Reduction of Area, %
950	57	310,000	240,000	3	7
1000	54	290,000	235,000	7	28
1050	52	265,000	226,000	8	32
1100	46	220,000	189,000	11	38

Creep and Rupture Properties of H-11 Die Steel

Test Temperature, F	Stress for Rupture in 10 Hours, psi	Stress for Rupture in 100 Hours, psi	Creep Stress for 0.001% Per Hour Secondary Rate, psi
800	214,000	205,000	195,000
900	195,000	175,000	130,000
1000	155,000	100,000	45,000

Chemical Composition, %

Type	C	Mn	Si	Cr	V	W	Mo
H-11	0.30-0.40	0.20-0.40	0.80-1.20	4.75-5.50	0.30-0.50	...	1.25-1.75
H-12	0.30-0.40	0.20-0.40	0.80-1.20	4.75-5.50	0.10-0.50	1.00-1.70	1.25-1.75
H-13	0.30-0.40	0.20-0.40	0.80-1.20	4.75-5.50	0.80-1.20	...	1.25-1.75

CUT ALONG THIS LINE

Edroc

(CONTINUED FROM PAGE 43)

that the teacher has the dual problem of staying abreast of current scientific advances and of finding both the time and the means of integrating the teaching of these advances in his science curriculum. Therefore an effective course in rocketry must:

1. Prepare the teacher to instruct effectively.
2. Be directed toward the average student.
3. Fit into the normal science curriculum.

But, and this is a big "but," it must also satisfy the demands of the advanced student. The approach taken to meet these requirements was the development of a safe classroom rocket demonstrator, a series of experiments of varying complexity, and a textbook on the internal and external ballistics of rocketry written for the high-school level.

Rocket Demonstrator

Before discussing the manner in which these elements are integrated to produce an effective over-all rocket course, let's take a look at the rocket demonstrator shown on page 43. Called the "Edroc," for educational rocket, the demonstrator operates on compressed-air oxidizer and propane fuel. This gas-gas system was chosen for the following reasons: (1) Ease of propellants delivery to the combustion chamber; (2) ease of injection and mixing of propellants; (3) narrow combustion limits, and therefore a high degree of safety; and (4) availability of propellants.

The rocket engine is constructed on a 17 x 11 in. chassis in "breadboard" fashion. All fuel lines are copper and all oxidizer lines aluminum. The fuel system utilizes a standard propane torch bottle that can be purchased in any hardware store for about $1.50. The flow of fuel to the combustion chamber is controlled by a 110-v AC solenoid valve. A bourdon-tube gauge displays the fuel pressure upstream of the solenoid valve; under no-flow conditions this is the vapor pressure in the propane bottle. The fuel is delivered to the combustion chamber through a metering orifice located in the combustion-chamber inlet fitting and is injected into the chamber through a single hole in the center of the chamber.

On the oxidizer side, compressed air is delivered from any source (school-laboratory air supply, small compressor, or compressed-air cylinder) through a regulator, rated for inlet pressures up to 3000 psia, to a solenoid tied electrically in parallel with the fuel valve. A gauge shows regulated oxidizer pressure upstream of the solenoid valve. When the solenoid is opened, the oxidizer is delivered to the combustion chamber. The normal solenoid restriction serves as a metering orifice in the oxidizer line.

Air is injected into the chamber through a single hole in such a way as to set up a vortex action. With the air swirling around the inner wall of the combustion chamber and the fuel injected along the longitudinal axis, the inner chamber wall is insulated from high-temperature gases. With this method of injection, the uncooled aluminum chamber of the Edroc engine can be run at steady-state conditions with the only cooling being natural free convection, even though the propellants are burning at a temperature of about 4000 R.

Combustion gases discharge through a DeLaval nozzle drilled in a standard fitting and threaded into the combustion chamber. This design permits simple replacement of the nozzle. Performance variation due to nozzle configuration and size can thus be readily studied. Propellants are ignited in the chamber by a standard spark plug. Chamber pressure is displayed, as mentioned, on a bourdon-tube gauge.

During operation, the only moving component is the combustion-chamber assembly. Fuel and oxidizer lines, the only structural members holding the chamber assembly, are formed to act as sections of a spring. When the engine is operating, the chamber assembly bears against a rubber diaphragm covering the mouth of a liquid-filled thistle tube. The pressure of the chamber against the diaphragm causes liquid displacement in the thistle tube. This displacement is amplified in a capillary tube connected to the end of the thistle tube, and can thus be calibrated for thrust.

Edroc is operated by a single switch which opens the two solenoid valves and provides power to the spark plug from an induction coil. Major operating characteristics of the unit are given in the table on page 43. A malfunction of any type during operation is not harmful or dangerous. A late ignition spark, for example, will result in normal or no combustion, depending on propellant mixture in the chamber. During a 10-month development program, malfunction and reliability tests were made to insure complete safety of operation.

The integrated teaching program utilizes the Edroc as a classroom demonstrator in several ways. During the regular science curriculum, basic principles—such as electromagnetism in the solenoid valves; Hooke's Law in the suspension of the thrust chamber; and electrical induction in the spark coil—are demonstrated on the Edroc before a firing. When rocket technology is discussed, the unit is first displayed to show how a rocket engine is made, and then run to show what an engine looks like in operation. During operation, the mixture ratio may be altered by throttling the propane supply valve. Variations in flame color, flame pattern, chamber pressure, and thrust can be noted as the unit runs from oxidizer-rich through the stoichiometric point to fuel-rich. The performance of the nozzle can also be demonstrated by varying nozzle-size configuration.

Program's Purpose

This program serves to present the fundamentals of rocketry to the average student. The teacher can expand on these demonstrations from the theory presented in the accompanying textbook. For the advanced student, the textbook can be used as the basis for a complete course in rocketry, perhaps given in a school rocket club after hours. The Edroc is integrated in this type of course with a set of more advanced experiments keyed to the textbook.

The textbook concludes with a chapter on advanced propulsion systems. This is designed to guide the seriously interested student into the college courses which will be of most value to him should he decide to work in the rocket industry upon graduation. Problems of navigation, communication, and vehicle design are also presented for the student with related interests. When a student has completed the study of the text and Edroc, he has an excellent theoretical and experimental background in rocketry.

It is hoped that this integrated approach to rocket technology will serve not only to inform the average student of the sciences which shape his world but also to provide the interested student with the knowledge required to direct his studies toward future participation in the advancement of space exploration. ♦♦

Meeting Papers Being Accepted

The ARS Program Committee is accepting papers in the Propellants and Combustion and Liquid Rocket fields for a meeting to be held at Ohio State Univ., July 18–19. Completed manuscripts should be sent to Program Committee Chairman, John Sloop, Chief, Rocket Engines Branch, NASA Lewis Research Center, 21000 Brookpark Road, Cleveland 11, Ohio, and received by April 4.

CUT ALONG THIS LINE

Flight Surgeon

(CONTINUED FROM PAGE 35)

The occupant of the cockpit is regarded as a slightly higher type of experimental animal, chosen either for small stature, physical hardihood, or presumed resistance to psychological stress. There would be merit in this approach if our objective were simply to somehow get a human being into space soon. But expose these theories to the light of our guiding principle and they dry up and blow away. What we need for a long-range program is an intelligent engineer-pilot in that spaceship. We need a technical expert operating at peak efficiency, fully understanding the mathematics of the situation, exercising his own judgment and making intelligent observations, and giving a report of not simply raw facts and impressions to be analyzed by ground personnel but an integrated account made by a trained mind. Let's not forget the history of test piloting. The first test pilots were simply men brave enough to go up in a biplane and come down in a parachute and tell the engineers, "I pulled on the stick and the whole damn thing came apart." Gradually it was discovered that, although courage and alertness were as essential as ever, a good test pilot had to know as much about the plane as the men on the ground.

The logical conclusion of this train of thought is that, if the physical rigors of spaceflight are going to be so great that only a female psychotic Eskimo jockey can withstand them, we had better get to work to widen the safety margin and comfort margin so that ordinary human beings can function at reasonable efficiency.

Publicity Prey

The same type of thinking also reduces to its true proportions the selection problem. No doubt the first man in space will be a world hero. His name will be on the front pages, his picture on the cover of "Life"; and I'm sure if he makes a successful re-entry Ralph Edwards will ride up on a convenient porpoise and say, "This is your life!" This is inevitable but unfortunate, because the role of the first astronaut is not much different from those who will follow him. If space exploration is a permanent continuing program, it follows inevitably that of the spacecrew candidates in the holding facility not one but *all* will go.

All will go. That certainly eases the decision problem for the facility commander and his medical advisers. And puts it in a new light as well. Some slight physical superiority or psychological edge will not be considered a controlling factor. It will be taken for granted that the small group of candidates, so carefully selected in the first place, can be brought to approximately the same level of physical fitness and psychological stability needed for the mission. Choice of the first pilot will most likely be on the basis of his technical background and training. Command will recognize that just as important as the first spaceflight are the second, third, fourth, and seventy-first.

Our guiding principle is also of help in another difficult area. Every flight surgeon experiences situations where his responsibility as an officer may be in conflict with his responsibility as a physician. It serves no purpose to form *a priori* judgments balancing the claims of one duty against the other. Instead, intelligent planning can frequently make these two responsibilities reinforce rather than oppose each other. For example, as long as the astronaut is considered an experimental animal, an inert passenger or package able only to survive because of exceptional physical resistance and luck, the supervising physician's medical conscience is subjected to an intolerable ethical strain. With his charge exposed to disaster at all points of the flight, it becomes next to impossible for him to decide when to abort the mission. It is the life of the subject against the advance of human knowledge, and while in some cultures this would be an easy decision it is not so here. I would not like to be the flight surgeon in this dilemma.

If we adopt the view that space-

Table of Biomedical Variables to be Monitored During Spaceflight

- Television Monitor
- Electroencephalograph
- Electromyograph
- Galvanic Skin Response
- Electrocardiograph
- * Blood Pressure
- Plethysmograph (Photoelectric)
- Respiratory
  - * Rate
  - * Volume
  - * Carbon Dioxide
  - * Oxygen
  - * Helmet Pressure
  - * Suit Pressure
  - * Body Temperature

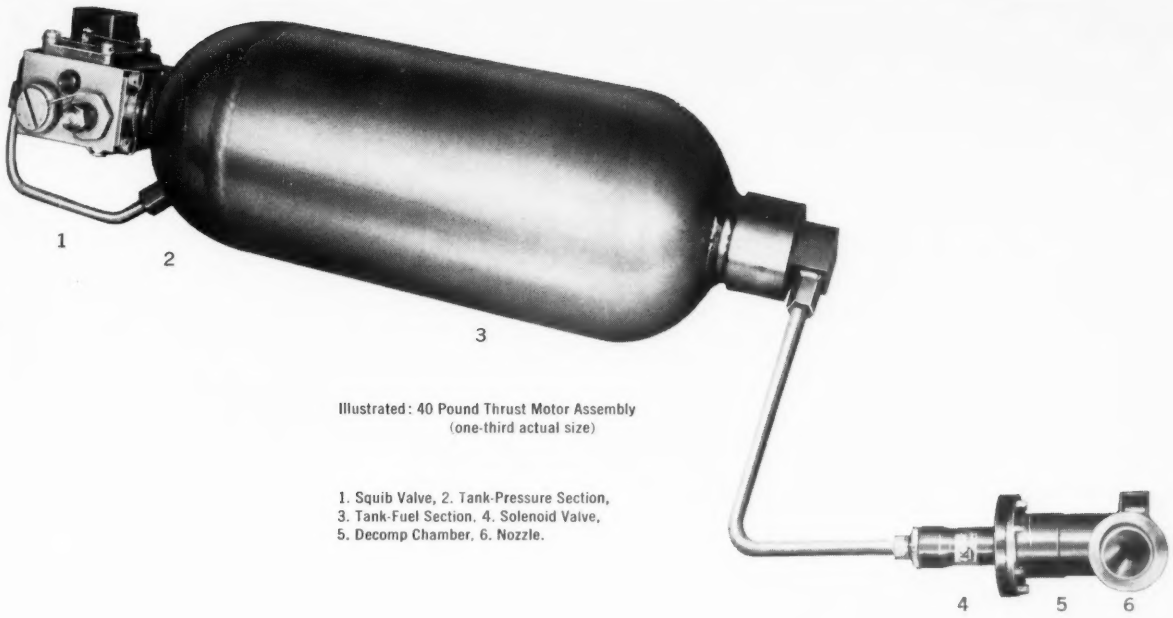
Corollary measures:

- Noise and Vibration
- Illumination
- Radiation
- Cabin Pressure
- Cabin Temp and Humidity

* Digital presentation if necessary.

Organization Chart of Medical Department of Holding Facility

SENIOR MEDICAL OFFICER
consultation and advice to FACIL OMMANDER
JUNIOR MEDICAL OFFICERS
1. Bd. certif. Psychiatrist and Aviation Medicine
2. Bd. certif. Internist and Aviation Medicine
MEDICAL STAFF
1. Aviation physiologist
2. Aviation psychologist
3. Biochemist — bacteriologist
4. Veterinarian (for correlation with animal experimentation)
5. Dietician (for training table and inflight feeding problems)
6. Clinical lab technicians
7. Medical electronic specialists
TECHNICAL CONSULTANTS
1. Physical chemist (closed ecological system)
2. Industrial hygiene expert
3. Electronics engineer
4. Personal equipment design and fabrication expert
5. Thermodynamicist and aero-thermo-dynamicist
6. Educational advisor
7. Safety advisor
8. Physical training



Illustrated: 40 Pound Thrust Motor Assembly
(one-third actual size)

1. Squib Valve, 2. Tank-Pressure Section,
3. Tank-Fuel Section, 4. Solenoid Valve,
5. Decomp Chamber, 6. Nozzle.

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Rocket Nozzle and re-entry materials
High temperature chemical kinetics
Combustion thermodynamics
High temperature structural plastics and ceramics
Advanced structures

SYSTEMS DEVELOPMENT

Aerothermodynamics
Re-entry programs
High temperature heat transfer
Penetration systems
Hyper environmental test systems

ELECTRONICS AND ASTRO SCIENCES

Astro navigation
Space communications and communication satellites
Instrumentation, telemetering and data reduction
Space environmental physics
Advanced techniques and system studies

TACTICAL WEAPON SYSTEMS

Infrared systems. Transistor circuit development

Qualified applicants are invited to send resumes and inquiries to Mr. G. B. Eaton, Aeronutronic, Dept. 20, Box 451, Newport Beach California.

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flight is a long-range step-wise program, however, the situation is changed. The pilot will be a trained astronaut. Risk to his life will be minimized by providing a very reasonable factor of safety. Every engineering attempt will be made to make continuous progress toward spaceflight and reduce discontinuous leaps into the unknown. Fortunately, there are several experimental aircraft that represent stages on the way to true manned spaceflight.

Data on zero-gravity situations, prolonged exposure to g-forces, closed system problems and so on will be available to the flight surgeon in increasing amounts. He will utilize this data to fill in our areas of ignorance, and will therefore have some rational basis to judge what is an allowable hazard for spaceflight.

The flight surgeon's position will still be a difficult one, although not on the level of the man in orbit. But a doctor is always in a much better position to weigh risks and take unavoidable chances if the avoidable ones have been reduced to a minimum. If the first man launched into space survives without injury, it should be a tribute more to the flight surgeon's planning than his nerve.

A Continuity

Seen thus as a long-range, continuously self-correcting and developing program, space medicine is simply a continuation of aviation medicine. The ideal aerospace surgeon is then not some kind of superman with a digital computer brain and IBM fingers, broadly qualified in seventeen specialties including parasitology, psychopathology, and astrology, but a natural extension of the aviation flight surgeon.

The classic concept of the flight surgeon as man and physician officer is expressed in Maj. Gen. Harry G. Armstrong's words: "He must be courageous and reasonable in propounding his opinions and advice, and prepared to defend them with facts and logic. The integrity of the individual must be unquestioned and his loyalty to duty and to those to whom he is responsible must be above reproach. Finally, the flight surgeon must have that depth of human understanding which will naturally cause those for whom he is responsible to turn to him for guidance and advice in time of stress or need."

This specification advisedly makes no mention of technical qualifications. These can be taken for granted. It is self-evident that the aerospace surgeon must have a working knowledge of the many disciplines and departments reporting to him, that administrative experience such as hospital command will be extremely useful, and that he meet certain professional requirements, which can be inferred from the organization chart on page 88. But the things that are going to really count are his integrity and resourcefulness in a new and rapidly changing field, his ability to win the trust of the men for whose lives he is responsible, and his sense of dedication to one of the boldest ventures in human history.

So you see that, beginning this paper by pitying the poor space surgeon's plight, I have wound up admiring and envying his fortunate position. ♦♦

Intl Space Committees

(CONTINUED FROM PAGE 27)

organized by ICSU for the purpose of coordinating international research in the fields of rockets and satellites.

COSPAR members met for the first time in November 1958 in London. At its second meeting, held in the Hague last March, it was unanimously agreed to revise the committee's makeup, which had been objected to by the Soviet Academy of Sciences, one of the original members. The charter revision approved in December was adopted at a meeting of the group's executive committee in Amsterdam last November.

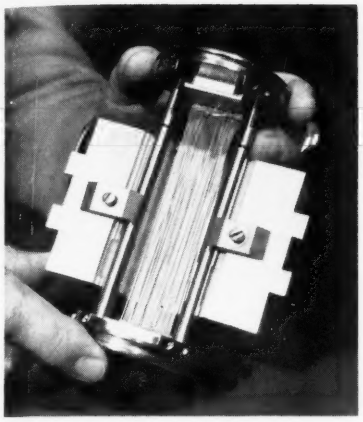
Under the new charter, COSPAR membership is now open to any national scientific institution adhering to ICSU which is active in space research. Nine international scientific unions also participate in COSPAR. The executive council will consist of nine representatives, together with a bureau made up of a president, a U.S. vice-president and two members chosen from a list drawn up by him, and a U.S.S.R. vice-president and two members selected from a list drawn up by him.

Soviet Cooperation Sought

Elections were scheduled to take place at Nice, France, last month at the first COSPAR meeting held under the new charter. At the same meeting, final makeup and responsibilities of working groups, which have been functioning until now in provisional form, were also to be decided upon.

UN and COSPAR officials were hopeful that the action taken in December would insure Soviet participation in both committees, and pave the way for true international cooperation in the field of space research. ♦♦

A Lung for Spaceflight



Strands of fine, hollow nylon thread form part of an "artificial lung" being developed by Hamilton Standard Div. of United Aircraft for experiments in removing carbon dioxide from the breath of astronauts. The photo shows a model of an experimental lung.

Rensselaer Offering Graduate Astronautics

Graduate study in astronautics is now offered at Rensselaer Polytechnic Institute. Its program includes a wide variety of courses and a number of seminars on special topics in the departments of aeronautical engineering, biology, chemistry, electrical engineering, mathematics, mechanical engineering, metallurgical engineering, and physics. Plans of study suited to the interest and scholastic background of each student are developed.

In announcing the program, Clayton O. Dohrenwend, dean of Rensselaer's graduate school, said that a limited number of fellowships, scholarships, and research assistantships are available to deserving applicants. Further information on the program may be obtained from the director of admissions.

Submarine and Space Medicine Symposium Proceedings Due

Proceedings of the First Intl. Symposium on Submarine and Space Medicine, held in September 1958, at New London, Conn., will be published in the near future. The 836-page volume will consist of papers by 50 contributors, including 10 from foreign countries. A special publication price will be offered to those subscribing to the book in advance. For additional information, write to Karl E. Schaefer, U.S. Naval Medical Research Lab, U.S. Naval Submarine Base, New London, Conn.

A New Role for The Mature Scientist

. . . in a unique Military Systems Organization created by RCA The fundamental mission of RCA's newly organized Advanced Military Systems Department is to develop new systems concepts that will satisfy military operational requirements in the period beginning five years in the future. In the establishment of this new department, all problems—e.g. organization, personnel, support, operating practices, and relations with other RCA departments—have been approached and solved with the firm objective of optimizing the ability of Advanced Military Systems to fulfill its mission. The result is, we believe, a unique organization operating in a uniquely creative environment.

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Missile market

By Jerome M. Pustilnik, Financial Editor

"YOU TAKE the high road and I'll take the low road," might have been the Missile Index's theme song last month, the Tax Collector conducting. Certainly tax considerations set the tone as investors established profits and took losses on cue.

With many aircrafts close to their lowest prices in several years, tax-loss selling, which lowered their prices further, depressed the Missile Index 1.6 per cent while the Dow-Jones Industrials climbed 3.0 per cent. Those missile securities which fared well were either near their highs or responding to their own special situations (Marquardt Corp.'s promotion to a New York Stock Exchange listing, for example).

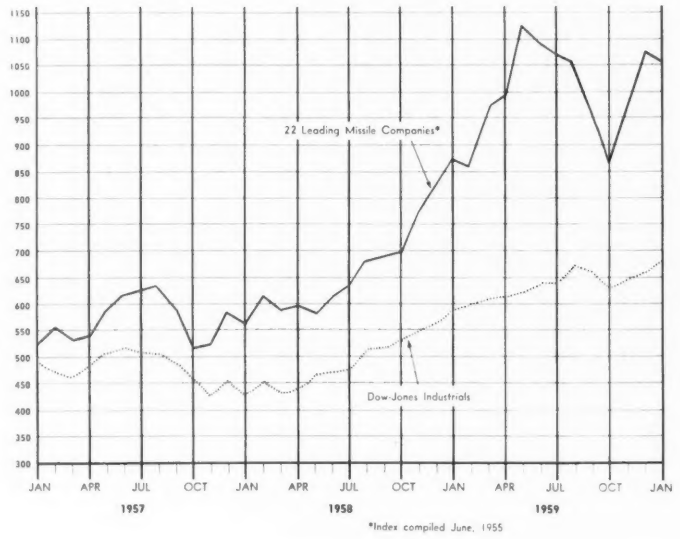
Investors seem to be shifting their funds from relatively high-priced electronics, missile, and so-called "glamour" issues into steel, railroad, and heavy industrial shares. Confirming this trend is the narrowing of the difference between the Missile Index's year-to-year percentage gain and that of the D-J Industrials. Only four percentage points separated them last month against almost fifty last June. This shift from one stock group to another has been speeded by the settlement in steel, which may become inflationary once presidential elections are safely out of the way.

Missile industry investors should heed the amber light, and investors should reappraise their holdings if they have not already done so: Review earnings progress, compare expectations with results, and reevaluate each company's prospects under today's conditions.

Accepting its own advice, this column's reappraisal of securities it has discussed this past year follows:

Aeronca Manufacturing has seen the cancellation of the F-108 and the de facto cancellation of the B-70 programs for which it was to have supplied brazed stainless-steel honeycombing. Although earnings for the first six months of 1959 were as anticipated ($0.57/share compared with $0.58 a year ago) full-year earnings will be about $1/share, down from the $1.10 originally estimated. The recent acquisition of Buensod-Stacey, designers and manufacturers of custom air conditioning, will add more than $12 million to Aeronca's sales. Aeronca's 1960 earnings, including Buensod-Stacey, could exceed $1.30/share. The stock retains some attractiveness.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	January 1960	December 1959	% Change	January 1959	% Change
Dow-Jones Industrials	679	659	+3.0	584	+16.2
Missile Index	1059	1076	−1.6	881	+20.2

Garrett Corporation, which was discussed recently, has reported earnings of $1.36/share for the first quarter of its current fiscal year compared with $0.44 the year before. The regular quarterly dividend was supplemented with an extra of 20 cents/share. Garrett's prospects, buttressed by diversified missile activities (more than 30 different programs) are exceedingly favorable and the stock is recommended.

General Precision Equipment is this column's most recent selection. Management has publicly estimated 1959 earnings of $2.50/share, which compares with barely breaking even last year. More than $4/share seems in prospect for 1960. A regular quarterly dividend of $0.25/share, the first since December 1958, has just been declared. And Martin has bought more GPE stock, increasing its ownership to 16.3 percent. GPE appears unusually attractive and this column recommends it again.

Progress is evident at **Kawecki Chemical,** too. Both sales and earnings expanded vigorously during the first six months of 1959 for this important producer of tantalum and other refractory metals; and an initial 3 percent stock dividend was paid. Sales were $3.5 million (against $1.8 million) and earnings were $0.59/share (against $0.12). Earnings for the full year will be at the lower range of the $1.25 to $1.50/share estimate made in June, increasing to $2.50 to $2.75 this year. Although long-range prospects are excellent, the current market price values present earnings adequately. The stock can be retained if it is already owned, but new positions should be deferred.

Last year was a busy one for **Martin Company.** They announced their complete withdrawal from the aircraft business. The rumor-racked Titan program was endorsed by the Secretary of Defense. Together with Boeing they won the Dynasoar contract. A 5 percent stock dividend was declared. A substantial amount (183,700 shares, or 16.3 percent of

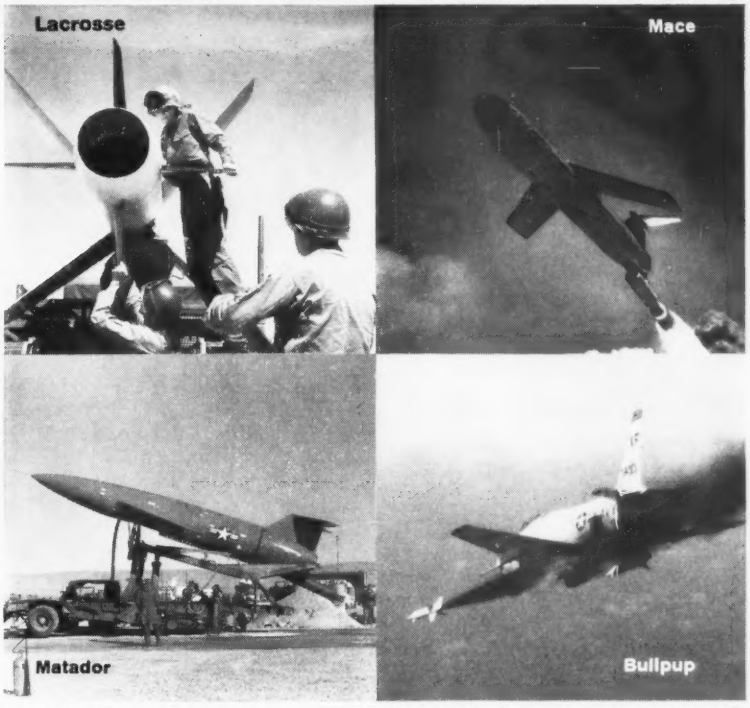
(CONTINUED ON NEXT PAGE)

For Moon Talk

Human factors engineer Francis J. Conley of Martin-Baltimore holds a miniaturized UHF radio transmitter developed by the company and mounted on a pilot's helmet for experimental purposes.

Further development, according to Martin, could make the transmitter suitable for a lunar-suit communications system. Martin engineers believe a lunar-suit transmitter should have signal strength proportioned to oral volume, range limited to distance normally reached on earth by a shout, an antenna pattern resembling normal voice propagation, and a switching arrangement to permit omnidirectional, full-power transmission in an emergency.

BUILT BY MARTIN



FOUR OPERATIONAL MISSILES

Missile Market

(CONTINUED FROM PRECEDING PAGE)

the total) of General Precision Equipment stock was purchased. And earnings spurted, as projected, to $3.22/share from $2.50 for the first nine months. Martin's prospects are favorable and the stock remains attractive.

Northrop's earnings were almost 10 percent lower in fiscal 1959—$4.01 against $4.31—but this had been anticipated. Management estimates sales will decline again in fiscal 1960, but that earnings will remain about the same, although, for the first quarter, earnings were only $0.80/share compared with $0.92. Northrop's backlog increased to $275 million on October 31, 1959 from $204 million as recently as July 31, 1959. And more than 60 percent of sales are in missiles and electronics business. Nonetheless, there is scant market interest in Northrop, or any of the medium-sized aircrafts for that matter. While the stock is reasonably priced in relation to earnings, it seems likely to remain that way.

Sangamo Electric has fulfilled this column's projections on earnings and dividends. At the end of the third quarter earnings of $2.68/share, compared with $0.77, were reported; and the original estimate of $3.75 to $4.00 for 1959 should be exceeded modestly. The recently increased dividend was boosted again only a few weeks ago, to $0.45/share quarterly. A major supplier of electrical equipment to the public utility industry and a prominent producer of sonar and other anti-submarine warfare gear, Sangamo could earn about $5/share this year. The favorable outlook for Federal spending on ASW, brightened by a reasonable price/earnings ratio reveals that Sangamo remains unusually attractive for current investment as well as for long term holding.

♦♦

Telemetry Working Group Issues New Newsletter

The Telemetry Working Group of the Inter-Range Instrumentation Group is issuing a new newsletter in an effort to improve communications between itself and other groups in the telemetry field. The first issue, prepared at the group's regular meeting at Pt. Mugu, Calif., held in 1959, contains a brief description of TWG and its objectives and a progress statement in areas of major interest—standards, frequency allocation, specifications, the tape testing development program, etc.

Thermoelastic Properties Of Metals and Alloys

Two simple dynamic techniques—one utilizing a pendulum to test wire specimens and the other sonic vibrations to test rods and prisms—have been adapted by the National Bureau of Standards for deriving thermoelastic data on metals and alloys for springs that will operate over a wide temperature range.

Open Letter

(CONTINUED FROM PAGE 30)

to make an electrical firing system? Do you know how to design a rocket nozzle or to calculate how much pressure you're going to get inside your combustion chamber or how to tell if your motor will take that much stress? And are you aware that zinc and sulfur, besides being a lousy fuel, is as treacherous as nitrogycerin because it can cause a dust explosion when you mix it; and that when you ignite it in a rocket, it produces something akin to a low-order explosion which can proceed to detonation in an instant if you don't have everything perfect?

Now you've got a legitimate gripe coming: "What's this guy yakking about?" Or rather, "Why is he?"

I know how you feel when your folks or other adults tell you to leave rockets alone for a few more years—I'm 18. I just graduated from high school and I'm now a physics major at Stanford Univ. I've also been in amateur rocketry for seven years. I've served twice as an officer of school rocket clubs, including a year as president of the Highland Rocket Society of Albuquerque, N.M. I've designed, built, flown, or supervised, as range controller, more rockets than I can remember. I'm proud of my record, for the AMERICAN ROCKET SOCIETY estimates that a rocket amateur has a one in seven chance of getting killed or maimed each year he experiments. I've got my eyes and fingers, and no one has ever been hurt at a launching I've helped run. I beat the odds and I'm quitting while I'm ahead! Remember, since I beat them, some other guy probably didn't.

Three Classes of Amateur

What kind of an amateur are you? The Highland Rocket Society lists three classes. The first two it tries to keep out of its membership: The first, or "Basement Bomber," is a guy who fools with rockets either for the publicity or just because rockets are dangerous. The second, or "Go-Go" type, is in the business to see something fly, the higher and faster the better. Last comes the serious guy who does it to learn something. We don't have a name for him, just a description. He's interested in science, knows high school chem and physics, loves them and math too. He likes to tinker but knows and practices the scientific method. His room is cluttered with handbooks, textbooks, and slide rules, and his wastebasket is full of original designs that he discarded. Lastly, there is a gleam in his eye when he looks at the moon, for he would give anything to go there.

You tell me now that you're sold; no more boom-boom for you. You know that everything you can learn about rocketry is already in the books. Besides, you want your hands and eyes so you can get into science and space in a few years. But, you say, you're still interested in rockets and you want to experiment yourself. What can you do? Answer: Lots of things!

There are dozens of safe projects. Of course, they don't involve live propellants. One of the most interesting involves the construction of a sealed Co_2-O_2 balanced system—a space cabin in miniature—for a mouse. Lots of amateurs have tried to fly "mouseniks," but most kill the animal on takeoff or lose the rocket or have it blow up. Did you ever stop to think that you can learn everything about the flight-life of a mouse, and a lot more, on the ground, and with a lot less trouble and expense too? You can simulate every condition of flight, save freefall, on the ground—heat, acceleration, even radiation!

On the surface the cabin looks easy—just a transparent box that can be sealed airtight, some green plants, and a mouse. But as soon as you start thinking about it, some problems arise, not the least of which is bringing the mouse into your house. (If you can enlist a biology teacher, things will be much easier on this point.) There are, however, some really first-rate technical problems to solve. How do you get food and water into the chamber; and once you get them in, how do you get the inevitable waste matter out? Also, how can you control the humidity and temperature of the chamber, remembering that a living animal gives off not only CO_2 but also water and lots of heat?

Design for Mouse

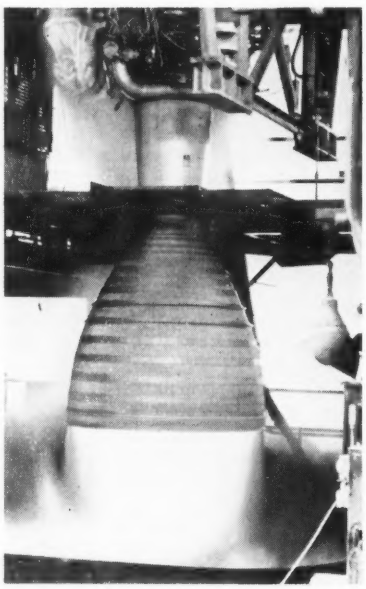
There are also a few minor problems such as instrumenting the chamber and the mouse to find out how it reacts to the intentional changes of air composition, temperature, pressure, and humidity which you will surely want to make. And of course you have to balance the animal's carbon dioxide production exactly to the plants' consumption and the plants' production of oxygen to the animal's consumption. And you have to do all of this without letting the least bit of air into or out of the cabin and system.

If you know enough about rockets, you might try designing some. It's a lot more work than just stuffing a tube with powder, but you'll learn more by sitting down and calculating the exact dimensions of a rocket than you will in any amateur flight-test. After you've designed the rocket, you'll certainly want to know how it will perform; so use the equations of physics to calculate velocity, altitude, range, and accuracy for your bird. I've "flown" rockets more than 100 miles this way. It doesn't sound so exciting; but, if you're in rocketry to learn something, you'll surely learn much more this way.

I hope I've made my point. It's possible, even probable, that someone reading this is recovering from a rocket accident. If so, I'm genuinely sorry. I only wish this could have reached you a little sooner.

But keep interested in amateur *astronautics;* play it safe; and keep your hands and eyes. Remember the first rule of engineering, "Anything that can go wrong, *will.*" Maybe you won't be the first man in space, but at your seventeenth birthday you can become accepted into the "brotherhood of astronauts." You can earn, as I did, the right to wear the badge of a student member of the AMERICAN ROCKET SOCIETY. ♦♦

400,000 Pounds of Thrust



Contributing information on combustion, turbomachinery design, and system operation for very powerful liquid-propellant engines is this 400,000-lb-thrust Rocketdyne rocket motor, shown here in the first released photo of a static-firing. The engine is not scheduled for any specific vehicle as yet.

Low-Thrust Space Vehicles

(CONTINUED FROM PAGE 26)

acceptable.

It seems that a number of opportunities will arise for application of ion propulsion systems within the next years. There will be a need for a light, small low-thrust unit to apply minor corrective forces to satellites requiring orbital parameters of high precision over a long period of time. Communication satellites, stationed in 24-hr orbits or at lower altitudes, have this requirement. The electric power will be available upon demand from the satellite's communication-equipment power supply. The ion system would be used first to obtain high-precision orbit parameters and later to maintain them against perturbations.

An ion system becomes superior to a chemical or a compressed-gas system for satellite orbit correction when the total velocity increment, generated over the satellite's active life, is of the order of 100 m/sec or more. For lower velocity increments, chemical or compressed-gas systems will be lighter.

It should be mentioned that plasma propulsion systems, using an arc jet to produce thrust, will take an intermediate position between ion systems and chemical motors. They may prove very useful and efficient as corrective systems for satellites.

As our civilization progresses, earth-bound communication systems will prove more and more inadequate. It is very possible that the 24-hr satellite corridor, at 40,000-km altitude, will develop into a place which abounds with heavy communication equipment installed and operated by telephone and telegraph companies for civilian traffic. While chemically propelled vehicles with one or two stages have considerable capability for placing heavy loads into orbits of a few hundred kilometers altitude, it takes a sophisticated and very powerful three-stager to put even a modest payload into a 40,000-km orbit.

Heavy Loads Transported

A low-thrust ion system is naturally qualified to transport a heavy load from a low into a high orbit. Beginning operation in the low orbit, it would transfer the load along a spiral path, would gradually change its orbital plane until arrival in the desired plane of the high orbit, and would finally adjust the orbital parameters to the required values. Having completed this mission, the propulsion system would detach the payload and return on a steep spiral to the low orbit, where it would replenish its cesium propellant and load another big package for the haul into the high orbit.

On the basis of parameters mentioned, the spacelift system could transport a payload package of 50 tons from a 400-km to a 40,000-km orbit in about 23 days with a propulsion system weighing only 22 tons. The return trip of this "tow truck" would take 6 days. The powerplant of the system would develop 4.5 megawatts of electric power.

The vehicle would be guided by a combination of inertial and radio components. It would be unmanned, but the loading of new propellant and payload in the low orbit would be done with human assistance.

Payloads larger than 50 tons can, of course, be hauled to the high orbit, either by allowing a longer transfer time or by applying a more powerful thrust system. One challenging mission for this spacelift system might be the transportation of an inhabitable 24-hr satellite into the high orbit after its assembly in an orbit close to earth. The human inhabitants would make the trip in a small, but fast, chemically propelled vehicle to avoid excessive exposure to the Van Allen radiation.

A logical extension of the spacelift system will be a ferry system that can carry heavy payloads to the moon. Again, chemical systems can make the trip quickly, but they are severely limited in carrying capability. Even though this idea may still sound a little eerie today, I am convinced that in a number of years there will be a human colony on the moon. It will be too small to relieve the earth of its excessive population, but it will be inhabited by the same species of hardy, undaunted men that are now crossing the Amazon jungle or the Antarctic snow plains. At least the newcomers among them will be Americans, and they will still find, I hope, some remote corners on the lunar surface where they can stake out their claims and build their igloos.

Operation Moonlift

Once we have established a bridgehead on the moon, we must maintain an Operation Moonlift to supply the colony with food, oxygen, building material, and equipment for explorations. Again the ion propulsion system offers a very attractive method of transporting heavy loads from a low-altitude satellite orbit to the close vicinity of the moon. Descents would be made with the aid of chemical

BUILT BY MARTIN

FIRST FULLY OPERATIONAL ELECTRONIC AIR-DEFENSE SYSTEM

braking rockets. The ion propulsion ferry would return to the earth's orbit, where it would be reloaded for the next trip.

A typical ferry vehicle might have the following design parameters. For a payload of 100 tons, the ferry alone would weigh 36 tons. An electric power of 6 megawatts would take the vehicle to the moon in 52 days, and back in about 8 days. An artist's conception of this kind of ferry is shown on page 25.

To Mars and Venus

Probably the most challenging mission for an ion propulsion system is a manned flight to Mars or Venus. A Mars ship would first spiral around the earth until it obtained sufficient velocity to escape the gravitational pull of the earth. From then on, it would follow an outbound spiral around the sun until it covered about half the distance between the earth's orbit and the Martian orbit. Thrust would then be reversed and the vehicle would spiral toward the Martian trail, as indicated in the trajectory diagram on page 25. A few thrust maneuvers would lead to the capture of the vehicle by the Martian gravity field, and a close spiral around the planet would finally bring the spaceship into the desired satellite orbit around Mars.

A manned expedition to Mars would be made with several ferry vehicles traveling together. Some would carry landing craft for the descent to and the ascent from the Martian surface. Others would be packed with instruments, equipment, and fuel for the exploration of the planet. Assuming that each vehicle carried a payload of 150 tons, the total initial mass per vehicle would be 435 tons, and the trip from earth to Mars would take about 300 days. The return trip would last 260 days, provided that again 150 tons of payload was carried, mostly consisting of samples collected on the planet.

It is interesting and very encouraging to note that the travel time of an ion ship to Mars would not be much longer than that of a chemically propelled ship. The travel time of the latter is essentially equal to the transfer time along a Hohmann ellipse, which is 260 days. This difference should not be significant. The travelers on a Mars ship will certainly not be the type plagued by boredom, and they will probably not mind if the travel time on their ionically propelled vehicle is 15 per cent longer than it would be on a chemical vehicle. After all, the ion ship provides them much more room to live and move around in; it gives them a greater weight allowance, a very generous supply of electric power for instruments, guidance and control equipment, and household machines; and a very gentle and easy way of guiding the ship continously along the desired flight path.

An artist's conception of ionically propelled Mars ships appears on page 26. The living quarters are mounted at the periphery of the radiation cooler. They rotate slowly, but fast enough to give the passengers a gravity field of about 0.2 g. This field should help them greatly toward a pleasant, enjoyable life aboard the spaceship.

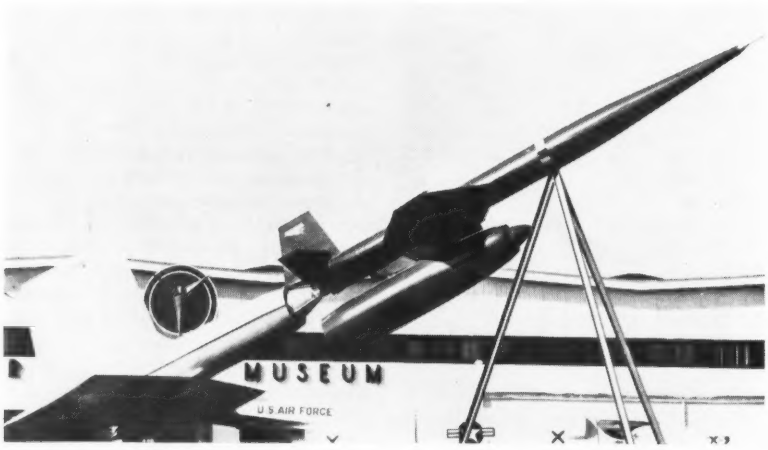
The guidance of a space vehicle of this kind will pose no particular problem. The basic element is a stabilized platform which keeps itself oriented toward the fixed stars. This platform carries several optical seekers which stay aligned with the Sun, the Earth, Venus, Mars, Jupiter, and possibly other planets. Their angles with respect to the stabilized platform are continously measured. Since the positions of the planets with respect to the sun and the other fixed stars are known for every instant from ephemerical tables, the exact location of the ship can be determined at every instant from the measured angles. This location, in three-dimensional space, will be continously compared with the desired precalculated flight path. As soon as deviations occur the thrust vector of the ship will be changed accordingly.

Round-Trip Times

A round trip to Mars will take almost the same time for a chemical rocket as for an ion ship. The longer the distance, the more the ion ship will be superior to the chemical one from the standpoint of travel time. A relatively small unmanned probe to Jupiter would need a Hohmann transfer time of 2.7 yr; if propelled by an ion system, it could be in a satellite orbit around Jupiter 1.5 yr after it left the earth. With a payload of 1 ton, its total mass at takeoff would be about 5.5 tons. Once in the Jupiter satellite orbit, the probe would discontinue its propulsion, and the full electric power would be available for measurements, thermal control, television pictures, and data transmission.

A similar probe to Saturn would require a Hohmann transfer time of 6.1 yr. If equipped with an ion propulsion system, it could begin transmission of data from a Saturn orbit about 2.5 yr after takeoff from earth.

Finally, we think of a probe going out into deep space, measuring radiations, meteorite impacts, and magnetic fields. If the probe is to reach the outskirts of the solar system—Pluto, say, at a distance of 6×10^9 km—its initial velocity, if launched chemically, must be of the order of 43 km/sec. Even with a multistage rocket, such a velocity would be very difficult to achieve, and the coasting time of the vehicle would be of the order of 45 yr on a Hohmann ellipse. With an initial



The Fastest Ramjet

The X-7 test vehicle, developed by Lockheed Missiles and Space Div. to evaluate ramjets and other components for advanced AF interceptor missiles, holds two major records for airbreathing vehicles—highest speed (above Mach 4) and highest operational altitude (still classified). The X-7 test vehicle has been chosen for the Air Force museum at Wright Patterson AFB, Ohio.

velocity of 50 km/sec, this time would be reduced to about 25 yr. An ion ship would be very greatly superior to a chemically powered vehicle. A payload of 1 ton could be sent to the distance of Pluto in 3 yr with a vehicle that leaves the earth orbit with a total mass of 16 tons and with an electric power supply of 2 megawatts. The guidance system in that case would be particularly simple, since it would need only guide the vehicle radially away from the sun. Any lateral drift would be of no concern. The instantaneous distance could possibly be determined with an earth-based radar and a repeater beacon aboard the probe.

Chemical System Merit

If we now compare chemically and electrically powered vehicles as to relative merits, we find one very definite advantage on the side of the chemical system: It exists. We have been obtaining experience with liquid-propellant rockets for 20 yr, and the amount of knowledge is impressive. It is true that chemical rockets still blow up once in a while on the pad or fail to reach their targets; but generally we feel pretty much at home in the art of building and operating chemical propulsion systems. Electric systems have not had a failure yet, but they cannot score one successful flight either. It will take a few years before the first electric engine operates in space and some more years before we can think of entrusting human passengers to an electric ship to Mars. However, we should be confident that the engineering problems will be solved and that by 1970 or 1975 electrically propelled vehicles will populate the space around the earth.

Once electric systems are developed to a satisfactory state of reliability, I believe that they will have a substantial appeal to space engineers, space explorers, and space travelers. First, there will always be a generous amount of payload. Lunar ferries will carry a useful payload of two-thirds takeoff weight, and Mars ships one-third. Second, there will always be plenty of electric power around for guidance, communications, observing instruments, kitchen equipment, thermal control, and other utilities. Third, the living space for human passengers will be ample, since the payload capacity of the vehicle is large. Fourth, guidance of the vehicle along the desired flight path will be convenient and simple because the vehicle is continuously on powered flight. Fifth, there will be no periods of disagreeable acceleration or deceleration during flight. Sixth, there are no re-ignition problems after long coasting periods through space. Seventh, the flight times to targets as distant as Jupiter, or farther out, will be substantially shorter than flight times of chemical ships.

There is one very definite weakness of electrical propulsion systems: The entire thrust-producing plant must operate continuously on an electric power level of the order of megawatts for a period of years. Repair, even though possible, would be difficult. It is very likely that this requirement will pose some very tough engineering problems. However, we should not forget that our refrigerator systems usually run for 10 yr or longer without trouble; that turbogenerator sets have been operated for decades without maintenance; and that even a normal motor car sometimes achieves an outstanding record of carefree service. Besides, a manned trip through space will always be undertaken by a task force of several ships. If it should happen that one of them has a major breakdown, the crew would transfer to one of the other ships and continue its mission.

I do not believe that a decision between chemical and electric ships can, or should, be made. If you want to move from this room to the coffee shop, or to the anticoffee shop, you can make no better choice for transportation than your legs. If you wish to go to the airport, you take a car. If you have to be in Boston tomorrow morning, you use the nighttrain. The best way to go to California is by jet plane; but if you have to ship a heavy piece of equipment from here to Los Angeles, you send it by boat. It would be an impossible idea to eliminate any one of these methods of transportation. Even among the flying vehicles we find balloons, airships, helicopters, propeller planes, and jet planes. Can we afford to drop any one of them?

The electric propulsion system will come into life on its own right, not as an all-out competitor, but as another powerful tool for the exploration of space. It should not be developed because it meets very exactly one specific requirement which can be defined today in all its minute details, but because it is, like many other essential developments in our history, a part of the natural technical evolution. The time when we should ask whether it is feasible, I believe, lies already behind us, and all we should do now is to accept the challenge wholeheartedly, and to respond with our best effort.

♦♦

In print

Introduction to Rocket Technology by V. I. Feodosiev and G. B. Siniarev, translated from the Russian by S. N. Samburoff, Academic Press, New York and London, 1959, 344 pp., illustrated. $9.50.

This is indeed a strange book. Sporting a photo of a Bomarc on the jacket, it appears with no indication as to when it was published in the U.S.S.R.; with photos of U.S. missiles casually inserted into the text and no reference made as to whether or not similar photos were used in the Russian edition; with some ghastly errors in transliteration from the original text which indicate that the translator has little background in the subject (Eno-Peltri" for Esnault-Pelterie, "Zenger" for Sänger or Saenger, etc.); and with the metric physical units used in the Russian text converted for some strange reason to the foot-pound-second system in all chapters except those dealing with chemistry.

The result is a product which is neither fish nor fowl. What the translator and publisher have succeeded in producing is a book which is neither an adequate representation of what began as a basic Soviet text on rocket technology, designed, as the authors explain, for the reader with a general background in physics, chemistry, and the fundamentals of higher mathematics, nor a textbook which improves appreciably on those already available on the subject.

The text itself is straightforward enough, beginning with a brief history of rocketry (naturally stressing Russian contributions, with Goddard and Oberth receiving only passing mention) and proceeding to a consideration of the theory of reactive motion, types of jet-propelled vehicles; types of reaction motors; fuels; combustion chamber processes and flow of combustion products through the nozzle; forces and moments acting on the rocket in flight; flight trajectory; stabilization and steering; and ground equipment and launching devices.

Of special interest is a list of 27 references, which includes a number of translations of foreign works (to the Russians), including those of Eugen Saenger here (transliterated correctly), George Sutton and Hermann Oberth, published as Foreign Literature Publications, Defense Publications, Military Transactions, etc.

It is unfortunate that the publisher and translator saw fit to take what might have been a worthwhile book and turn it into a mish-mash which adds little or nothing to the already overflowing library of basic publications on the subject.

Early Nike-Zeus Test Vehicle

Shown being launched recently at White Sands is this early test vehicle of the Army's anti-missile missile, Nike-Zeus. The shot was for development purposes.

War for the Moon by Martin Caidin, E. P. Dutton, New York, 1959, 258 pp., illustrated. $4.95.

The prolific Martin Caidin is at it again, this time with a work purporting to tell "the inside story of the U.S. and Soviet lunar probes and man's coming flights to the moon." Perhaps the pace is beginning to tell on the author, now turning out books at the rate of almost half a dozen a year, but this latest effort is not one of Caidin's outstanding successes.

The book is devoted largely to detailed (and sometimes rambling and discursive) descriptions of AF and Army lunar probe attempts, supplemented by some background on the problem and on the moon itself. No one writing in this field today is Caidin's equal in describing the tense hours of a countdown or the excitement inherent in the launching of a space vehicle, but here the descriptions overpower the book's stated purpose.

Caidin is a polemical writer, who feels very strongly that this country should and could have been first in space and first to reach the moon. This premise underlining every line he has written, is one against which there is simply no defense. However, he has marshalled stronger arguments to prove his point elsewhere, notably in "Countdown for Tomorrow." Here he has merely told the bald story of our failure.

Outstanding in the book are the illustrations, and there are lots of them. Included are a series of beautiful, albeit somewhat fanciful, paintings by Fred L. Wolff; a large number of handsome black-and-white drawings by Bert Tanner; and some spectacular photographs.

The intriguing title and illustrations are likely to win the author some new readers among laymen, but there is little here to interest the specialist in the field.

—I.H.

BOOK NOTES

The Space Age is rapidly spawning its own library of reference books. Latest addition is **"Guide to the Space Age"** (320 pp., Prentice-Hall, $7.95) by C. W. and Hazel C. Besserer, a compilation of definitions of more than 5000 words and phrases taken from modern rocket, missile, and space technology. Written in clear, easy-to-understand language and extensively cross-referenced, the book, containing a good number of illustrations and reference tables, represents an attempt at standardizing commonly used words and terms. Not a space encyclopedia, it nonetheless offers more than adequate definitions of any terms you're likely to run across and constitutes a valuable addition to any reference library.

Mel Hunter, better known until now for his paintings (some have been used as *Astronautics* covers) than for his photography and writing, combines the last two talents in **"The Missilemen"** (192 pp., Doubleday, $4.95), a handsome word-and-picture story of the Cape that takes the reader on a behind-the-scenes report on the work (and play) of the men and missiles and space vehicles that are their

(CONTINUED ON PAGE 103)

High-Thrust Space Vehicles

(CONTINUED FROM PAGE 29)

orbit above Mars, and return to a low-altitude circular orbit about earth. For microthrust, it is assumed that the vehicle accelerates continuously at a constant rate, initially accelerating up to some peak energy and then decelerating. Departure from an earth orbit along any particular trajectory implies a particular increment of velocity added at departure and a certain Martian approach velocity, with a certain amount to be dissipated in establishing a circular orbit around Mars. For the high-thrust case, the sum of these two has been minimized by selection of a particular trajectory. Total travel time is precisely that; it does not include any required period of waiting in a Martian orbit to allow establishment of the return trajectory, and the assumption is made that travel times to and from Mars are identical. The latter restrictions apply equally to both micro- and macrothrust. As can be seen in the graph, total impulsive velocity required for microthrust is approximately four to five times larger than the high thrust case for equal travel times. This difference, then, is caused both by the previously mentioned inefficiency of gravitational escape under microthrust, and by the fact that a microthrust vehicle must accelerate to much higher peak energies to compete on an arrival-time basis.

The graph can be translated directly into useful load of a particular gross-weight vehicle by resorting to some rather simple equations. The total exhaust power of any rocket vehicle may be expressed by $P = g\ (TI/2)$ where the power P is in foot-pounds per second if thrust T and specific impulse I are in the conventional units of pounds and seconds, respectively. This power must be divided by the efficiency of the entire cycle to establish the required reactor power. For a nuclear rocket this efficiency will be nearly unity; for the turbine-generator-accelerator type of microthrust device, the over-all efficiency should be about 10 or 20 per cent. It is obvious from this equation that, while ion rockets are always associated with small thrust, they are not necessarily of small power.

Assume that we may break our space vehicle weight down in the following manner: $W_G = W_f + W_p + W_{U.L.}$ where W_f is the weight of expendable working fluid, W_p is the weight of the power generation equipment (nuclear reactor, turbine generator, accelerator, and radiator) and $W_{U.L.}$ is all the rest (useful load). The following growth-factor relation

may be derived from the simple impulsive velocity equation familiar to all rocketry

$$\frac{W_g}{W_{U.L.}} = \frac{1}{e^{-V_o/gI} - (IaC_p/45.8)}$$

Here V_o is impulsive velocity, C_p is the powerplant specific weight in pounds per kilowatt, and a is the thrust to initial gross-weight ratio. Also, C_p is assumed independent of specific impulse regardless of the class of electrical system used. While the formula is derived for constant thrust and power, as opposed to the constant thrust to mass ratio assumption used in the two graphs, it is approximately applicable so long as the fuel weight is not too large a fraction of the vehicle's gross weight. Inspection of the weight-breakdown equation indicates that for fixed values of the parameters an optimum specific impulse exists. Differentiation shows that the optimum specific impulse is defined by the implicit function

$$\frac{V_o}{g_o I_o}\ e^{-V_o/g_o I_o} = \frac{C_p I_o a}{45.8}$$

where I_o is the optimum specific impulse. It must be recognized that this optimum is true only so long as a constant specific impulse (constant power and constant thrust) is assumed, and that there can be slight improvements if optimum specific impulse programs are followed at constant power (See ref. 1). However, gains to be made by this route can be shown to be small, and the simple equations here are much more amenable to demonstrating broad conclusions.

It can be shown by means of the immediately preceding equation that the optimum specific impulse at the growth factor $W_g/W_{U.L.}$ = infinity is defined by V_o/gI_o = unit. Hence, the maximum possible fuel fraction is $1 - 1/e$, and the maximum possible variation of acceleration is from the initial acceleration a to 2.7 times a. Referring back to the graph on page 29 for a moment, it can be seen that a variation of acceleration by a factor of 2 or 3 does not grossly change the required total impulsive velocity. Hence, it is reasonable to employ the constant-acceleration assumption and to express growth factor in terms of the average acceleration.

Using the last two equations and the impulsive velocity requirements shown by the graph on page 29, the useful load of a basic 200,000-lb vehicle may be computed as indicated on the third graph on page 29. Two curves are

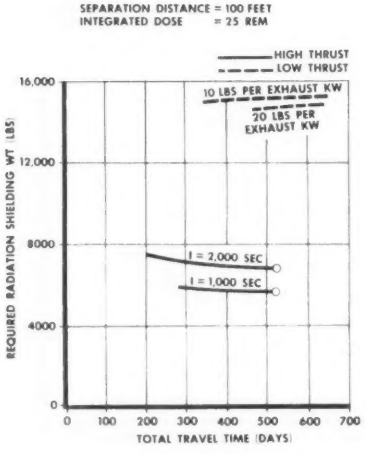
shown for microthrust, one at a powerplant specific weight of 10 lb/kw and one at 20 lb/kw. It is well to remember that powerplant specific weight in the growth-factor equation is the weight of the powerplant per exhaust kilowatt. Considering the efficiency of the turbine, the generator, and the accelerator itself, the area between 10 and 20 lb per exhaust kilowatt may be assumed to be reasonably optimistic since it implies only 2 to 4 lb per reactor kilowatt. For the high-thrust case, two curves of different specific impulses are shown, at 1000 and 2000 sec. It is believed that, within achievable reactor technology, specific impulses of 1000 sec can be obtained with hydrogen as a working fluid. Advances to 2000 sec or greater may require different reactor technology, perhaps even a gaseous-core reactor. As can be seen in the graph, the useful loads are comparable, with the low-thrust systems having the edge at long flight-times, while at short flight-times the high-thrust vehicles would seem better.

Power Potential

Further conclusions based on this curve alone usually degenerate to an argument over the achievability of microthrust machines giving 10 lb/kw as opposed to high-thrust nuclear rockets with specific impulses in excess of 1000 sec. Certain other differences in these systems are more pronounced.

By use of the first equation cited, it is possible to compute the total work expended by the reactor in either the macrothrust or microthrust case, shown by the bottom graph on page 29 in terms of megawatt-days versus total travel time. In the computation of total work, it was assumed that the thermal power of the reactor in the microthrust vehicle was five times the exhaust power and that the thermal power of the macrothrust vehicle was equal to the exhaust power. On the order of 10,000 to 16,000 megawatt-days would be required for the round trip of the low-thrust vehicle, and it can be seen that the difference between the total work of the micro- and macrothrust vehicles differs by a factor of over 100. A unit of megawatt-days was intentionally chosen since 1 megawatt-day represents approximately 1 gram of fissionable material consumed. The microthrust vehicles shown here would consume between 10 and 16 kg of fissionable material during a trip, whereas the assumed high-thrust vehicles would consume some 30 to 150 grams.

MARS ROUND TRIP REQUIRED SHIELDING WEIGHT

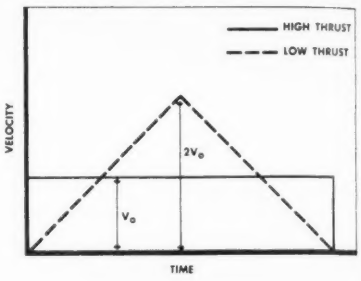


Since total power required by the microthrust reactor is in the neighborhood of 20 megawatts, an interesting point is apparent: For such a reactor the normal critical mass used in current design would be on the same order as that required of expendable fissionable material. A very high percentage of useful fuel in the reactor may make it difficult to achieve the very low specific powerplant weights cited in these figures and elsewhere, and would make the provision of excess fuel to permit repeated mission use very difficult. It may well be necessary to rebuild the reactor after each flight. The high-thrust vehicle, however, has a very nominal consumption of fissionable material on the order of 100 grams for a 1000-megawatt reactor. Even a conventional reactor should, therefore, possess a high re-use capability (See ref. 2).

The vast difference in total work out of the reactors gives rise to the question of how much shielding would be required to adequately protect passengers in such a vehicle. The graph at left shows the results of an attempt to arrive at an answer to this question. In the low-thrust case, it is assumed that shielding may be best done by locating the complete shadow shield near the reactor. In the high-thrust case, the shield is split between a shadow shield near the reactor and a well type about a small passenger compartment. Also included in the high-thrust shielding estimates is the effect of the hydrogen fuel acting as shielding material itself.

There is a vast difference in the shielding problem between the macro- and microthrust cases. In effect, the entire passenger compartment of the microthrust vehicle must be shielded, since the passengers will be under radiation for the duration of the trip. In the high-thrust case, the reactor

VELOCITY TIME RELATION FOR EQUIVALENT TOTAL TRIP TIME



functions at high power for only a few minutes with only a few more hours at reduced power for a sufficient cooldown cycle.

In the high-thrust case, then, it is necessary to shield the passengers for hours, rather than months, and the area or volume which must be shielded can be relatively small, since the passengers need remain in the shield volume only a limited time. As indicated in the graph shown above, the low-thrust vehicle will suffer a penalty of about twice the required shielding weight of the high-thrust vehicle. At best, a shielding estimate is only that—an estimate—without an extremely detailed design of the entire vehicle. However, this factor of 2 mentioned is dependent upon a very basic fact; the total work output of the microthrust vehicle's reactor is perhaps more than 2 orders of magnitude greater than the output of the equivalent high-thrust vehicle. The fact that the shielding penalty is only a factor of 2 is due to the large increase in shielding efficiency in the presence of large energy outputs.

The Reliability Facet

As noted in the foregoing discussion, a comparison of the useful load that can be carried by space vehicles of comparable gross weight does not present a very convincing argument one way or the other. The vehicles themselves are comparable in load-carrying ability on the basis of constant trip time. However, the short time of operation (except for the ecological system) of the high-thrust vehicle is important. Essentially, so far as the propulsion system is concerned, it need operate only for a few minutes at the beginning of the trip, and again for a few minutes at the end of the trip. The low-thrust system, on the other hand, must operate continually for many months. The job of designing propulsion equipment, and testing to develop its reliability, has always been a crucial problem. It has

been found by experience in rocket propulsion that static tests should be run which sum to an equivalent of perhaps 100 times the propulsion period of the vehicle in question.

Static-Testing Time

Now consider the case of microthrust, where the total trip times to Mars and return involve perhaps 2 yr of total powerplant operation. Clearly, operating the engine for a period of time equivalent to 100 trips is impractical, at least if we are going to get off this planet in the near future. But just as clearly, from what we know of the statistics of development, something like this would be required to insure reliable operation. Here then is a real trap in making a comparison between high-and low-thrust systems. While the time required to design, construct, and initially operate a high-thrust nuclear rocket and a large microthrust device might be roughly equivalent, the real time comparison between the development through static-testing for reliability of the two may vary widely. It could well be decades before real confidence in a microthrust unit was established, and even a reliable gaseous-core reactor might be achievable in the same time.

Clearly, the problems of propulsion reliability are somewhat simpler where the high-thrust vehicle is concerned, but there is an associated problem of perhaps equal significance, namely, the problem of navigation. It has been made clear by studies such as Ref. 3 that it is eminently feasible within the current projected state of the art to launch a high-thrust vehicle which coasts to within the near vicinity of Mars or Venus—that is, at least within the sphere of gravitational attraction of these planets. Other studies, such as Ref. 4, have made it clear that it is within the state of the art to construct a simple guidance system which will correct such errors of a few planet radii with essentially a terminal-navigation homing scheme. A complete interplanetary navigation scheme can thus be constructed with equipment which again has to operate for only a few minutes during the high-thrust phase of departure from earth and for only a few hours during the terminal homing procedure at the end of the flight. Clearly, in the case of microthrust, navigation will be required throughout the flight—constantly computing, constantly checking, constantly taking position readings for a matter of months. Most of the equipment in a high-thrust vehicle hibernates during the majority of the voyage. Only the ecological system, which must always work on any vehicle, goes continuously.

Recently, the subject of multiple engine reliability in rocketry—that is, the ability to complete a mission after one of a cluster of engines fails—has received considerable attention. In the macrothrust case, this is possible on interplanetary missions, since a change of thrust-to-weight ratio has little effect upon either flight-time or impulsive velocity required. But for the microthrust vehicle this apparently cannot be achieved without considerable sacrifice of useful load, because transit time is a strong function of acceleration and the goal is a moving target.

Multiple-Engine Effects

Referring again to the second graph on page 29, a change of acceleration from 2×10^{-4} to 1×10^{-4} increases transit time by about 230 days, or about half a Martian year. Hence, if a twin-engine microthrust vehicle were employed, it is probable that the entire trip would have to be planned and executed on one engine if the concept of multiple engine reliability were used. This means, of course, that the effective powerplant specific weight is doubled, and the third graph on page 29 indicates the penalty.

So far, we have only spoken of flights to the near planets, such as Mars and Venus, using the case of Mars as an example. One often hears the statement that microthrust units might not be too applicable to lunar

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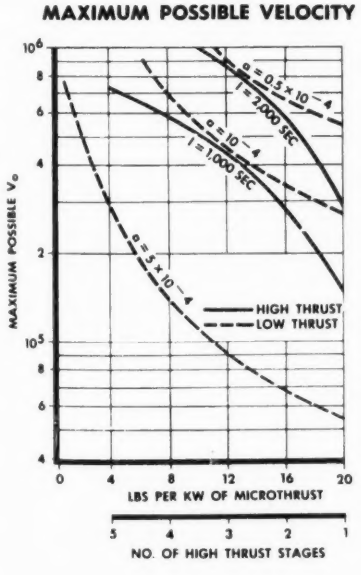
ONLY OPERATIONAL NAVY AIR-TO-SURFACE GUIDED MISSILE



trips, and perhaps might be only a breakeven proposition on near planetary trips. When considering exploration of the entire solar system, however, microthrust will really come into its own. The extension of rocket travel to great distances implies that higher and higher impulsive velocities are utilized.

Maximum Velocity

To investigate this point, it is instructive to consider the maximum possible velocity for various propulsion schemes. If one considers very large velocities, the loss due to escaping from the gravitational field of earth becomes a relatively small quantity for either high- or low-thrust systems. But to achieve the same distance in the same time, the low-thrust vehicle must attain a much higher total velocity than the high-thrust vehicle. As illustrated in the graph on page 100, this peak velocity of the microthrust vehicle must be approximately twice that of the high-thrust machine. Hence, a factor of 2 should be included when comparing high- and low-thrust vehicles for equivalent travel times. Such a comparison is plotted against powerplant specific weight for microthrust and against number of stages for macrothrust in the graph on page 101.

On the basis of complexity, it can be argued that three stages of a high-thrust rocket are no more complex than the reactor-turbine-generator accelerator and radiator combination represented by a microthrust machine. Clearly, very high velocity can be achieved by resorting to very small accelerations. But, neglecting for the moment the effects of the gravitational field, the distances covered by the microthrust device is one-fourth of the acceleration times the travel time squared, as indicated in the graph on page 101. Then, under this simple rule, at an acceleration of 10^{-4} it requires about 10 yr to complete a round trip to Pluto.

Hence, it is doubtful that thrust-to-weight ratios of less than 10^{-4} are useful for solar-system exploration. But this would also require an impulsive velocity of about 10^6 fps. Referring to the graph on page 101, it can be seen that such a requirement might be met by either a microthrust vehicle with a specific powerplant weight of about 4 lb per exhaust kilowatt or a four-stage high-thrust rocket with a specific impulse approaching 2000 sec.

Considering the previously mentioned difficulties of developing reliable equipment for long operation periods, it can be argued that, even for this extreme, microthrust and high-thrust vehicles for the mission would have equivalent developmental time scales.

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1. Irving, J. H. and Blum, E. K., "Comparative Performance of Ballistic and Low-Thrust Vehicles for Flight to Mars," Space Technology Laboratories. Presented at 2nd Annual Astronautics Symposium, Denver, April 28–30, 1958. (AFOSR). Published in "Vistas in Astronautics," vol. II, Pergamon Press.
2. Glasstone, Samuel and Edlund, Milton C., "The Elements of Nuclear Reactor Theory," 1952. D. Van Nostrand Company, Inc., Princeton, N.J.
3. Gunkel, R. J., Lascody, D. N., and Merrilees, D. S., "Impulsive Midcourse Correction of an Interplanetary Transfer," Douglas Aircraft Co., Inc., Santa Monica Div., Santa Monica, Calif., Engineering Paper No. 804, June 1959.
4. Stearns, E. V., "Interplanetary Homing," Lockheed Missiles and Space Div., Sunnyvale, Calif., July 1959. ♦♦

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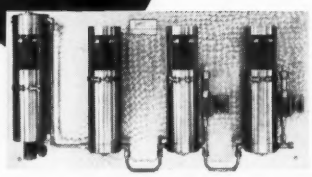

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(CONTINUED FROM PAGE 98)

charges. The photographs, many taken by Hunter and Bert Tanner, are superb, the text more than adequate, and the feeling that permeates the Cape when a big shoot is imminent has seldom, if ever, been captured more effectively. All in all, "The Missilemen" is a book worth having a look at.

RECEIVED

Observations on Nickel-Bearing Cosmic Dust Collected in the Stratosphere, by Herman Yagoda (12 pages, AFCRC, Bedford, Mass., March 1959; available from OTS, Dept. of Commerce).

Professional Engineer's Income and Salary Survey for 1958 (51 pages, National Society of Professional Engineers, 2029 K Street, N.W., Washington 6, D.C.; $2.00).

Unfired Pressure Vessels, Section 8 of the ASME Boiler and Pressure Vessel Code, updated from 1956 ($6.00 per copy from ASME Order Dept., 29 W. 39th St., New York 18, N. Y.).

Ballistik, by R. E. Kutterer (304 pages, Friedr, Vieweg and Sohn, Braunschweig—Burgplatz 1).

Mars Revisited, by Donald L. Cyr (131 pages, Dorrance & Company Inc., Philadelphia, Pa., $3.00). An introduction to Marsitrons (sic).

Boeing 707, by Martin Caidin (213 pages, Ballantine Books, New York, $0.50). Pocketbook. ♦♦

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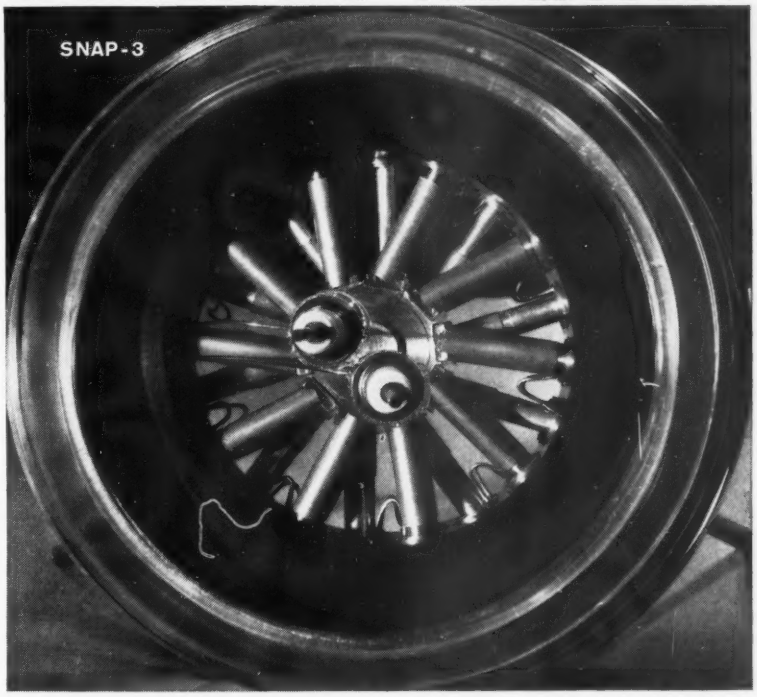

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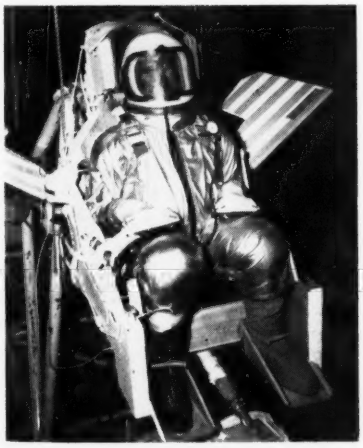
Publications Still Available At National Office

The ARS National Office still has available for sale to members the following publications:

Collected papers of the 1957, the 1958, and the 1959 National Telemetering Conferences (for $3, $4, and $6.50, respectively).

Proceedings of the first Colloquium on the Law of Outer Space, the Hague, 1958, Edited by Andrew G. Haley and Welf Heinrich (126 pp., Wien Springer-Verlag, $4.50).

Wings for X-15 Pilot



Two wing-like fins have been added by North American Aviation engineers to the X-15's ejection seat, as shown above with dummy pilot, to prevent its uncontrollable tumbling in a bailout. The fins are made of aluminum honeycomb produced by Hexcel Products Inc. of Berkeley, Calif.

Magic Million with Reinforced Plastic Cases

This one-piece reinforced plastic case showed a strength-to-weight ratio above one-million inches in recent tests by its maker, 3M's subsidiary the Zenith Plastics Co. of Gardena, Calif. Zenith believes solid-rocket motor cases capable of holding three million pounds of propellant and taking a total impulse of 10 million pounds thrust can be developed in two years. New reinforced plastics, says the company, will show even higher strength-to-weight ratio.

Contract awards

NAA's Autonetics Div. Gets $115 Million Minuteman Contract

The Air Force has awarded Autonetics Div. of North American Aviation a $115,000,000 contract for continued development, fabrication, and testing of Minuteman inertial-guidance and flight-control systems, and ground-support equipment. The award, covering mid-1958 to mid-1961, substantiates an earlier letter contract authorizing Autonetics to start work on the project.

In another contract from the Air Force, Autonetics has received $350,000 in initial funding for an autonavigator and auxiliary maintenance console simliar to that being produced for the Navy's Polaris submarines. This system will be used to improve the tracking of the Army's Pershing missile during test flights.

NAA also announced the signing of a $73 million letter contract from the Navy for additional A3J Vigilante jets.

Production of Bullpup And Pershing Continues

The Martin Co. has received a $22,600,000 Navy contract for continued production of Bullpup missiles and a $10,500,000 Army pact for continued work on the Pershing.

Basic Re-entry Vehicle Study by Avco

Avco-Everett Research Lab will continue basic studies applicable to ICBM re-entry vehicles under an additional $4,815,000 AF contract.

GCR Wins Solids Job

The Army announced that Grand Central Rocket Co. is the winner in the competition to convert and operate the Kansas Ordnance Plant at Parsons, Kans., to produce and load solid propellant motors, especially in the 5000 to 10,000 lb range for tactical missiles.

Two-Step Rocket for Red-Eye

A $400,000 contract for development of a two-step rocket for Red-Eye, the Army and Marine Corps' shoulder-fired antiaircraft guided missile, has been awarded to Atlantic Research Corp. by Convair-Pomona.

Titan GSE Contracts

Contracts totaling $3,065,000 for Titan ground support equipment, such as propellant loading systems, alarm and enunciator systems, and control and control valve equipment, have been awarded to the Compu-Dyne Corp. by the Omaha District, Corps of Engineers.

Chrysler Modifications To Jupiter and Redstone

The Army has awarded Chrysler a $1,525,000 contract for engineering work on Jupiter and a $521,828 contract to modify the Redstone.

Wallops Island to Get Intercommunication System

A $69,163 contract to build an intercommunication system for NASA's rocket launching site at Wallops Island has been awarded to Kellogg Switchboard and Supply Co.

Flight Instruments

Minneapolis-Honeywell Regulator Co. has received a $175,000 contract from WADC for six prototypes of an advanced miniaturized air-data display instrument system to be incorporated in WADC's integrated flight instrument panel for high-performance aircraft.

Grumman Gets $26 Million Pact

The Navy's Bureau of Naval Weapons has awarded a $26,365,776 production contract to Grumman Aircraft for additional WF-2 Tracers.

Wind-Tunnel Testing

CalTech was awarded an $825,000 Army Ordnance research and development contract for wind-tunnel testing.

Refractory-Metals Research

Harvey Aluminum announced that a contract is underway between the company and WADC's Materials Laboratory to explore basic parameters in the fabrication of refractory alloys, such as molybdenum, tungsten, niobium, and tantalum.

Static Inverters

The AF has issued a development contract to Hamilton Standard's electronics department for 100 VA static inverters which will be completely transistorized and weigh less than 5 lb.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, NASA, and Navy contracting office:

AIR FORCE

AFCRC, Laurence G. Hanscom Field, Bedford, Mass.

Research and development of computer programs for use in test of geodetic ob-

NASA CONTRACTS FOR OCTOBER

Contractor	Obligation	Program
AOMC	$150,000	Initial funding for design, construction, and integration of Juno-II-launched satellite to study energy and source of gamma rays.
	$150,000	Initial funding for design, construction, and integration of Juno II-launched satellite to sample ionosphere.
Ball Brothers Research Corp.	$250,000	Initial funding for instrumentation for Delta-launched earth orbiting solar observatory.
Jones-Mahoney Corp.	$110,000	Construct buildings for new NASA minitrack station at Ft. Myers, Fla.
MIT	$ 70,000	Basic research of noise phenomena associated with rocket launches and jet aircraft.
McGraw-Edison Co.	$ 80,000	Rotor repairs in unitary wind tunnel at Langley Research Center.
NBS	$130,000	Ground experiments with radio signals to determine properties of ionosphere.
	$ 70,000	Use of computing system services.
ONR	$ 70,000	Logistics and support for 100-ft-sphere communications satellite (Delta launched).
Navy BuOrd	$360,000	Purchase of 19 solid-propellant Scout motors for upper stages in AF high-altitude and re-entry tests.
Navy Weapons Plant	$ 50,000	Mockups for Goddard Space Flight Center.
Univ. of Cincinnati	$180,000	Advanced mathematical research into celestial mechanics.

servation programs and geodetic data reduction programs, $41,829, **Electronic Speciality Co.,** Systems Labs Div., 1485 Ventura Blvd., Sherman Oaks, Calif.

Analysis and interpretation of satellite meteorological data gathered over equatorial, tropical, and subtropical regions, $28,800, **Univ. of Hawaii,** Honolulu, Hawaii.

Research directed toward experimental and theoretical investigations of informational feedback and with respect to disrupted speech communications, $40,898, **Southern Illinois Univ.,** Carbondale, Ill.

AF Missile Development Center, ARDC Holloman AFB, N.M.

Telemetry ground station in support of project WS-133A, $59,908, **Electro-Mechanical Research, Inc.,** P.O. Box 3041, Sarasota, Fla.

AFMTC, ARDC, Patrick AFB, Fla.

Increase in funds, $80,000, **Dynatronics, Inc.,** P.O. Box 2566, Orlando, Fla.

Increase in funds, $517,074, **Convair-Astronautics,** 5001 Kearny Villa Rd., P.O. Box 1128, San Diego 11, Calif.

AFOSR, Director of Procurement, Washington 25, D.C.

Continuation of research on ultra-energy fuels for rocket propulsion, $70,852, **Aerojet-General,** Azusa, Calif.

Continuation of research on primary cosmic radiation and its interaction with matter, $73,195, **Univ. of Rochester,** Rochester, N. Y.

Continuation of research on rapid cosmic ray variations and solar effects, $28,000, **Univ. of Maryland,** College Park, Md.

Study of the properties of radioactive nuclei by optical orientation, $25,000, **Univ. of Illinois,** Urbana, Ill.

Continuation of basic research in microwave electronics, $38,650, **CalTech,** Pasadena, Calif.

Continuation of solar microwave research, $91,000, **Leland Stanford Jr. Univ.,** Stanford, Calif.

Research on aero-elasticity, $72,699, **Bell Aircraft,** Buffalo 5, N.Y.

Continuation of research on hypersonic viscous flow phenomena, $26,596, **Rensselaer Polytechnic Inst.,** Troy, N.Y.

Continuation of research on interaction of hydrogen and oxygen atoms with surfaces, $106,868, General Atomic Div., **General Dynamics Corp.,** San Diego 12, Calif.

Studies in linear systems, $26,394, **Harvard College,** Cambridge 38, Mass.

Experimental investigation of transverse combustion pressure oscillations in rocket motors, $38,515, **Purdue Research Foundation,** Lafayette, Ind.

Research in paramagnetic electron spin and microwave spectroscopy, $101,048, **Duke Univ.,** Durham, N.C.

Continuation of study of turbulent shear flows through swirling round pets, sweptback plane jets, and a possible method of generating homogeneous shear flows, $68,450, **Johns Hopkins Univ.,** 34th and Charles Sts., Baltimore 18, Md.

Research on growth of boundary layers in plasma accelerators, $59,505, **CalTech,** Pasadena, Calif.

Arnold Engineering Development Center, Arnold Air Force Station, Tenn.

Research and preparation of reports relating to a space environment simulation facility, $27,522, **Litton Industries,** Electronic Equipment Div., 336 N. Foothill Rd., Beverly Hills, Calif.

Research and preparation of reports relating to a space environment simulation facility, $32,570, **Arthur D. Little, Inc.,** Cambridge 42, Mass.

ARMY

Army Ordnance Dist., Birmingham, 2120 7th Ave., N., Birmingham 3, Ala.

Engineering and design services, ground support equipment, Saturn, Supplement, $431,970, **Hayes Aircraft Corp.,** P.O. Box 2287, Birmingham, Ala.

Lacrosse missile and related equipment, supplement, $80,900, **Martin Co.,** P.O. Box 5837, Orlando, Fla.

Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Target missile production, $3,437,200; target missile flight services, $32,500; **Radioplane,** A Div. of Northrop Corp., 8000 Woodley Ave., Van Nuys, Calif.

Design and development of combat vehicle weapons system, $8,617,624, **Ford Motor Co.,** Ford Rd., Newport Beach, Calif.

Modification of guided missile, $29,680, **Firestone Tire and Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

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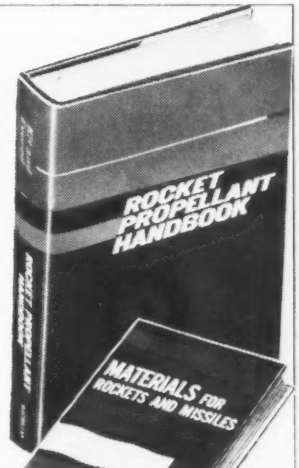

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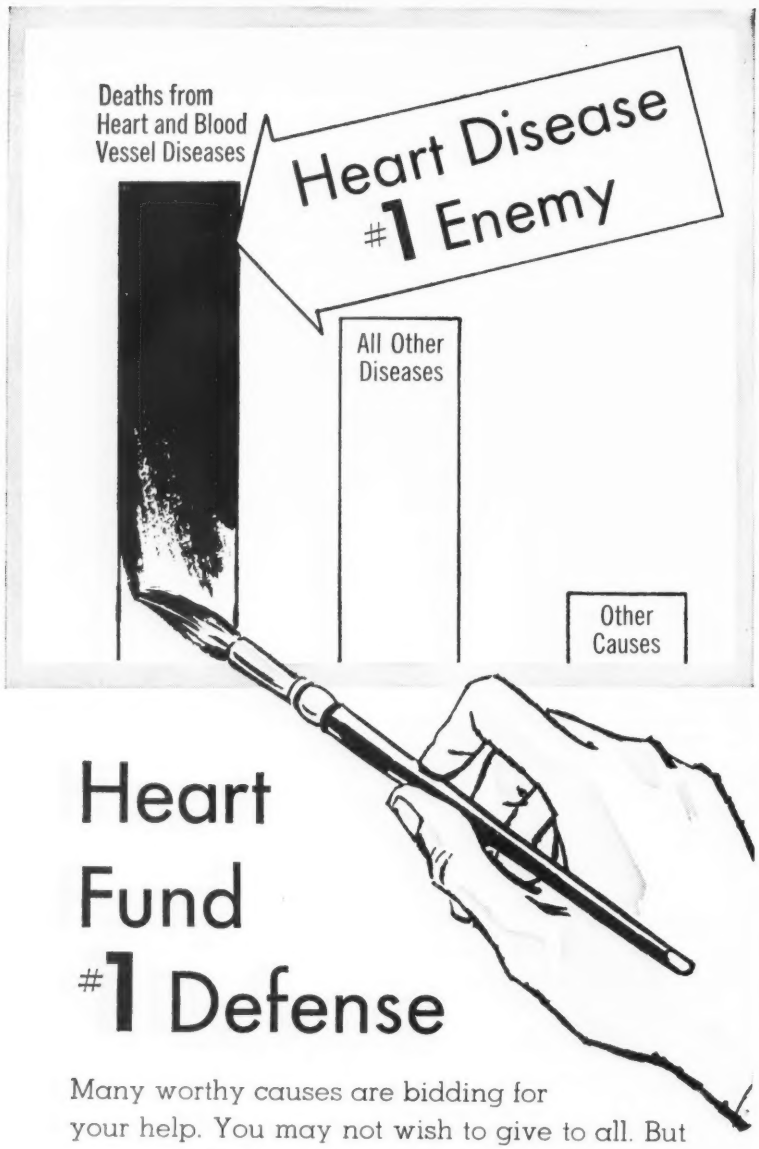

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Study of space vehicle vulnerability, $129,847, **North American Aviation,** 12214 Lakewood Blvd., Downey, Calif.

Hypersonic research, $30,000, **CalTech,** 1201 E. California St., Pasadena 4, Calif.

Army Engineer Dist., Los Angeles, 751 S. Figueroa St., Los Angeles 17, Calif.

Rocket engine test stand 1B at Edwards AFB, Calif., $4,721,786, **Del W. Webb Construction Co.,** 5101 San Fernando Road, Los Angeles 39, Calif.

Army Ordnance Dist., Philadelphia, 128 N. Broad St., Philadelphia 2, Pa.

Development and fabrication of a liquid propellant evaluator, $42,361, **Research Institute of Temple Univ.,** 4150 Henry Ave., Philadelphia 44, Pa.

Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala.

Radome Cover, $63,175, **Hoover Awning and Mfg. Co.,** 6921 N.W. 7th Ave., Miami, Fla.

Army Signal Supply Agency, 225 S. 18th St., Philadelphia 3, Pa.

Services and materials for one primary and two secondary satellite tracking stations, $300,000, **Collins Radio Co.,** Richardson, Tex.

Ground stations for Courier communication satellite system, satellite checkout facility, modification, $300,000, **Radiation, Inc.,** Melbourne, Fla.

Semiconductor device, diode, $33,942, **Transitron Electronics Corp.,** Wakefield, Mass.

Boston Ordnance Dist. Army Base, Boston 10, Mass.

Satellite tracking program, $80,959, **Smithsonian Institution,** Washington 25, D.C.

Engineering services, Hawk missile system, $5,733,975, **Raytheon Co.,** Waltham, Mass.

Procurement Branch, Aberdeen Proving Ground, Md.

Ballistic computer system, $47,897, **Allegany Instrument Co., Inc.,** 1091 Wills Mountain, Cumberland, Md.

NASA

Ames Research Center, Moffett Field, Calif.

Oscilloscope display for monitoring tunnel tests of 3.5-ft hypersonic tunnel, NASA, Moffett Field, Calif., $25,690, **ITT,** Industrial Products Div., 15191 Bledsoe St., San Fernando, Calif.

Lewis Research Center, 21000 Brookpark Rd., Cleveland 35, Ohio.

Magnetic tape recorder for Lewis Research Center, $36,120, **Ampex Corp.** 528 Vinewood Ave., Birmingham, Mich.

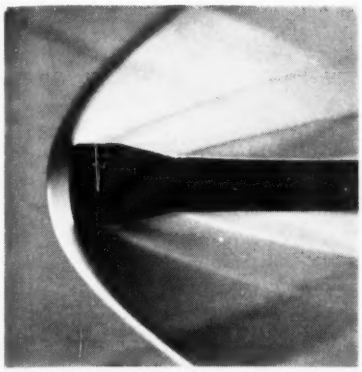
NAVY

Office of Naval Research, Washington 25, D.C.

Research on antennas and radiation, $65,000, **Univ. of California,** Berkeley, Calif.

Research on wind tunnel tests of ground effect machine models, $47,170, **Univ. of Wichita,** Wichita, Kan. ♦♦

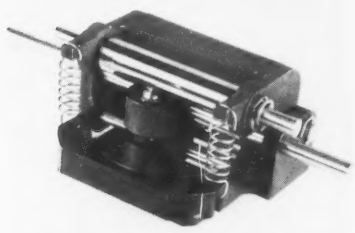
New equipment and processes



Student Aerodynamics: Developed for aeronautical education, the portable Model W test system includes a Varitunnel designed for blowdown operation from a 2000-psi dry gas source, a Schlieren optical system, an inlet-air heater, and test models. Its performance allows direct comparison of test results with supersonic theory, and the opportunity to conduct original quantitative investigations. Amrad, Inc., Box 254, Sewanee, Tenn.

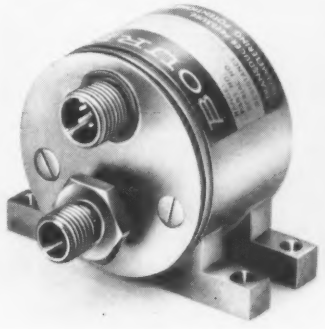
Rocket Rate Gyro: Model RG24-0103 gyro, smallest precision dc gyro with pot pickoff, is $1^5/_8$ in. in diam and $3^1/_2$ in. long, including Bendix connector. Designed for high altitude use, the instrument is hermetically sealed in a steel case. The motor runs on 28-v dc, 150-ma maximum current. It operates between — 65 and 180 F. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.

Mechanical Integrator: Because of its small size, the Model 031-2000 integrator is useful in computing systems. It is a compact, lightweight ball-and-



disc unit designed to save engineering time when used as a breadboard item in checking out system designs. Weight, 6.5 oz; disc input speed, 250 rpm; disc input torque, 0.33 in.-oz. M. Ten Bosch, Inc., 80 Wheeler Ave., Pleasantville, N. Y.

Absolute Pressure Transducer: Specifications on Model 717 are: Operating



temperatures, —65 to 200 F; pressure range, 0–400 to 0–5000 psia; resistances, 1K to 10K ohms; power rating, 1.5 watts at 165 F; resolution, as low as 0.17 per cent; static error band (linearity, friction, resolution, hysteresis and repeatability), as low as ±0.8 per cent; weight 14 oz. Bourns, Inc., 6135 Magnolia Ave., Riverside, Calif.

Propellant Loading Programmer: An electric switching system has been designed to program automatically and rapidly transfer of liquid propellants from ground storage facilities to the missile. The programmer consists of a maintenance panel, power distribution panel, three fuel-sequencer

Prefabricated Clean Rooms

Prefabricated clean rooms are now available in packaged form containing all the elements necessary to achieve and maintain a dustfree, constant-temperature, humidity-controlled environment, as required, for instance, by MIL-Std 120. The air-distribution system is engineered to prevent drafts; temperatures can be held to as close as plus or minus $^1/_4$ F; relative humidity can be held to 50 per cent or less; and lighting is designed to give a minimum of glare for close work. Various degrees of dust control are available, depending upon the requirement. Whole laboratories are sold on an erected basis. The labs can be dismantled and moved readily and can also be expanded with ease. Available from Packaged Laboratories Div., Agnew-Higgins Inc., 40 South Los Robles, Pasadena, Calif.

Above, a packaged lab recently installed at Sandia Laboratory, operated for the AEC by Sandia Corp.

drawers, and two liquid nitrogen-helium drawers. Minneapolis-Honeywell Regulator Co., Missile Equipment Div., Queen and S. Bailey Sts., Pottstown, Pa.

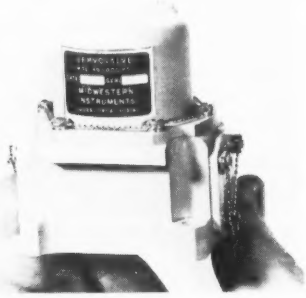
Special-Purpose Receiver: Types 1905 and 1906 miniature receivers feature tuners designed to produce an extremely low noise figure, and incorporate tuning structures capable of tuning 30 to 260 mc with uniform performance over the band. Type 1905

reception is AM and CW; type 1906 reception is FM, AM, and CW. Standard rock mounting size is 19 x $8^3/_4$ in. high. Nems-Clarke Co., 919 Jesup Blair Dr., Silver Spring, Md.

Miniature Telemeter Oscillator: Total power for the Model TOF-300 is 20-v dc at 5 milliamp. The oscillator is available in all standard IRIG num-

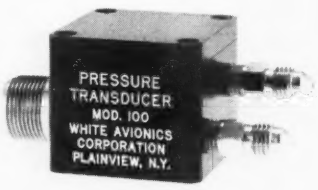
bered and lettered bands, and provides a measurement accuracy to within 1 per cent. The 1.5-cu-in. unit is applicable to AM/FM telemetering systems for missiles, space vehicles, and aircraft. Bendix Pacific Div., Bendix Aviation Corp., 11600, Sherman Way, N. Hollywood, Calif.

Flow Control Servovalve: An electromechanical servovalve weighing $9^1/_2$ oz has been designed as a connecting link between the electrical and the hydraulic systems in rockets, missiles, and aircraft. Model 40 has a rated



flow to 5 gpm at 1000-psi valve drop; rated current, 8 ma; rated power, 0.06 watt. Midwestern Instruments, P.O. Box 7186, Tulsa, Okla.

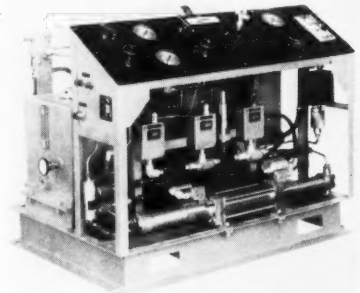
High-G Transducer: A potentiometric-output transducer capable of performance under high-g environment (to



50 g at 3 kc) is available to measurement-system designers. Giving infinite resolution, the 6-oz Model 100 has pressure ranges of 0–15 to 0–300 psi for corrosive and noncorrosive liquids and gases in a configuration $1^1/_2$ x $1^1/_2$ x $1^1/_4$ in. White Avionics Corp., Terminal Rd., Plainview, N.Y.

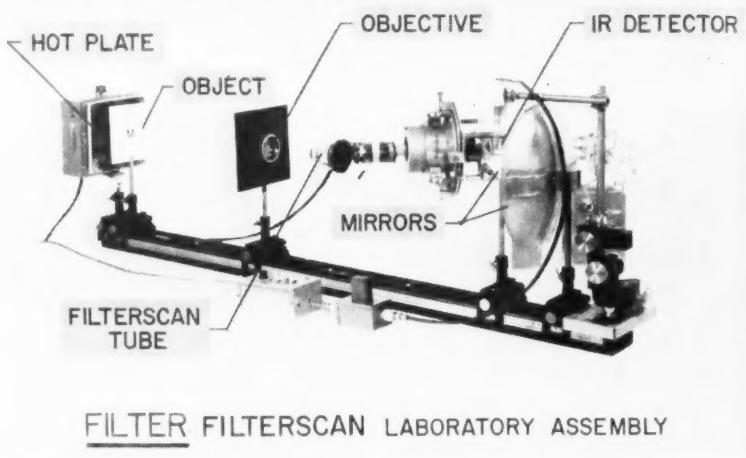
Oxides in Small Sizes: Sample quantities of iron oxide powder in the 200–1000 A size range are available. These and other finely particulated materials are the product of a broad development program using the high-intensity electric arc. Other materials produced are alumina and aluminum metal, silica, graphite, thorium oxide, thorium carbide, yttrium oxide, and ferrosilicon. Vitro Laboratories, 200 Pleasant Valley Way, W. Orange, N.J.

Gas Booster-Compressor: Model SS-III meets current requirements in missile and space vehicle programs where high-pressure inert gases must have extreme purity. Pressures to



10,000 psi are possible in the two-stage, 12:1 ratio unit without gas contamination. The booster is suitable for laboratory test work with any dry inert gas, including helium. Haskell Engineering and Supply Co., 1236 So. Central Ave. Glendale 4, Calif.

Infrared Scanning System Developed

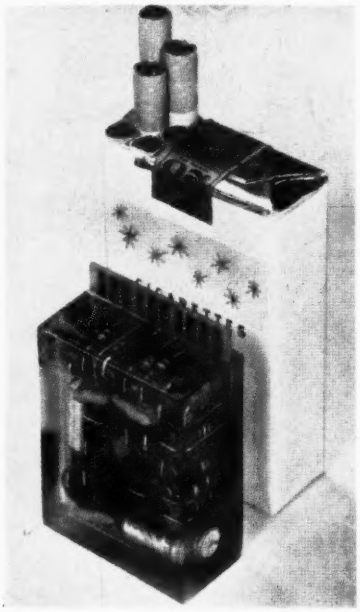


Laboratory setup for testing Filterscan.

Philco Corp.'s Research Div. has developed a method of reproducing electronically an image of the target seen by IR cells. Called Filterscan, the system offers good picture quality with a television-type image presented in a pattern of 150 lines/inch. The standard raster in television is a predetermined pattern of 525 lines/inch. According to Philco's IR specialists, the Filterscan image could be scanned at TV rates should applications call for the definition they would give. The system appears to have possible guidance and reconnaissance applications.

Digital Indicator: High-accuracy multichannel readout for measurement of flow, pressure, speed, or frequency with pulse-producing transducers are features of the Type 6R indicator. The instrument has an accuracy of ±0.25 per cent. Linearity is also ±0.25 per cent at any point over a 10 to 1 range. With four digit readout, the type 6R has a resolution of up to 1 part in 9000. Ten scale ranges are available. George L. Nankervis Co., Cox Instruments Div., 15300 Fullerton, Detroit 27, Mich.

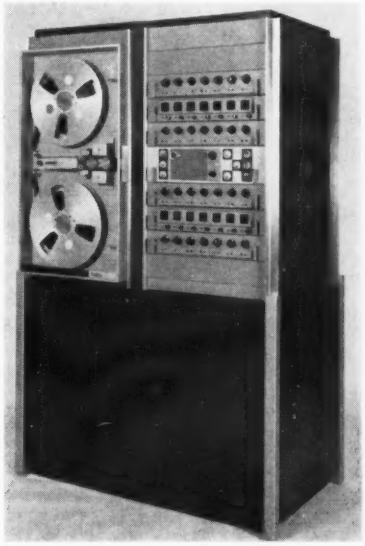
Monitor for Liquefied Gas: Basic components of a sensing instrument for monitoring and measuring liquid levels, and for liquefied gas level control, consist of a combination of probe-



Delta-C module unit, and a control which includes the power supply. The design of the sensor allows an intervening distance of as much as two miles between the probe and control-power unit. Heart of the sensor is the modular, one-piece epoxy-encapsulated unit measuring 2.5 x 2 x 1 in. Trimount Instrument Co., 3119 W. Lake St., Chicago 12, Ill.

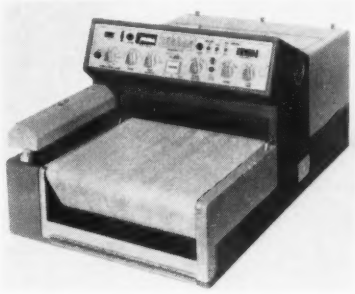
Programable Power Supplies: Three models, the PS-32, 33, and 34 are transistorized units designed to furnish well-regulated voltages from a programed source. The source may be a magnetic-tape reader or punched card, or manual selection from panel buttons. Voltages range from 6 to 36-v DC at 30 amp, 1 to 500-v DC at 1 amp, and 0 to 99.9-v DC at 1.5 amp. The power supplies are used in laboratory and production line test stands, preflight missile or airframe electronic systems checkout, and other checking. Southwest Industrial Electronics Co., Div. of Dresser Industries, Inc., 10201 Westheimer Rd., Houston 19, Tex.

Analog Tape Recorder: Special head design and advanced electronics design of the FR-600 permit direct recording of frequencies as high as 250



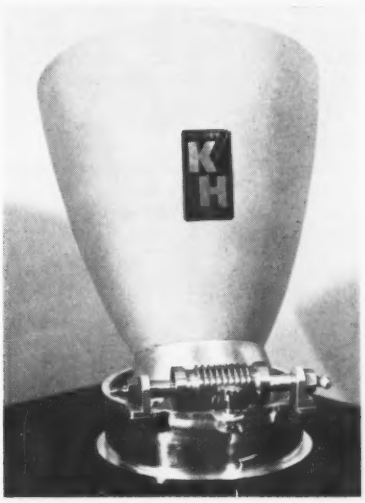
kc. FM response from DC to 20 kc within $^1/_2$ db is double that previously available. FM, pulse-duration modulation, direct, or digital recording modes are available through plug-in amplifier modules. Ampex Corp., Instrumentation Div., 934 Charter St., Redwood City, Calif.

Recording Oscillograph: Fifty channels of test data can be recorded on a 12-in. wide record with the Model 603 oscillograph. Record speeds are variable from 0.05 to 170 ips. Information is presented in seconds with



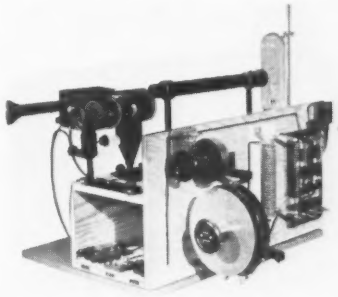
the instrument's recording-readout process, which requires no chemicals, powders, or heat. Traces are made visible by secondary exposure of the record to low-intensity light. The recording beams contact the paper in view of the operator, permitting visual monitoring. Midwestern Instruments, P.O. Box 7186, Tulsa, Okla.

On the Right Track



This integrated turret nozzle and actuator package has been developed by the advanced projects group of Kelsey-Hayes for thrust vector control of solid-propellant rockets. The company has also designed and tested pivoting nozzles and other devices for thrust vector control.

Pyrometer Calibrating Set: This set (Model 107) permits accurate and simultaneous calibration of any two optical pyrometers, regardless of manufacturer. A wide-filament strip lamp can be adjusted by step and



vernier rheostats to any temperature in the range from 1400 to 4200 F. It is furnished as a packaged set. Pyrometer Instrument Co., Inc., Bergenfield, N.J.

LITERATURE

Re-Entry Ablation of Reinforced Plastics. GE Missile and Space Vehicles Dept., Philadelphia, Pa.

A New Approach to Temperature Control of Hypervelocity and Space Vehicles—"Thermo-Lag." Electronics and Avionics Div., Emerson Electric Manufacturing Co., 8100 W. Florissant Ave., Saint Louis, Mo.

Large Single Metal Crystals. Flow Corp., 85 Mystic St., Arlington, Mass.

Selective Dissemination of New Scientific

Information with the Aid of Electronic Processing Equipment. IBM, Advanced Systems Development Div., Yorktown Heights, N.Y.

Rocket Propellant Combinations Using Hydrogen Peroxide. Becco Chemical Div., Food Machinery and Chemical Corp., Buffalo, N.Y.

Tetranitromethane. Hummel Chemical Co., 90 W. St., New York, N.Y.

Maintaining Energy Supremacy for America. Independent Petroleum Assn. of America, P.O. Box 1019, Tulsa, Okla.

Central Compression Systems Supplying High-Pressure Helium-Nitrogen—Air. Airdox Cardox Products Co., High Pressure Pneumatics Div., 307 N. Michigan Ave., Chicago, Ill.

Conversion Factors. Precision Equipment Co., 4409 B Ravenswood Ave., Chicago, Ill.

Kodak Materials for Aerial Photography. Eastman Kodak Co., Rochester, N.Y.

Logan Emergency Showers and Decontamination Showers. Logan Emergency Showers, Inc., Glendale, Calif.

Beckman Standard Electromechanical Breadboard Parts. Helipot Corp., Newport Beach, Calif.

How Magnetic Instrumentation Tapes of du Pont Mylar Polyester film provide maximum reliability. E. I. du Pont de Nemours & Co., Inc., Film Dept., Wilmington, Del.

Consolidated Primary Pressure Standard. Consolidated Electrodynamics, 360 Sierra Madre Villa, Pasadena, Calif. ♦♦

Hand Jet Carves Rock

The Linde Co. has adapted its patented rocket-jet torch to a small manual form that allows stone workers to do jobs considered impossible or uneconomical before. Known as Stone-Shaping, the technique can be used to shape monuments, gutters, copings, compound-angle slabs, etc. of the harder stones, such as granite, quartzite, and taconite.

A worker blasts away at a granite pier with Linde's new manual Stone-Shaping jet torch.

Index To Advertisers

Adel Precision Products 22
Page B. Otero, Inc., Los Angeles, Calif.
Aerojet-General Corp. ..... Back Cover
D'Arcy Advertising Co., Los Angeles, Calif.
Aeronutronic, A Div. of Ford Motor Co. 90
Honig-Cooper & Harrington, Los Angeles, Calif.
American Bosch Arma Corp. ..... 3rd Cover
Doyle, Kitchen & McCormick, Inc., New York, N.Y.
American Machine & Foundry Co., Government Products Group 1
Cunningham & Walsh, Inc., New York, N.Y.
Avco Corp. 21
Benton & Bowles, Inc., New York, N.Y.
Avco Corp., Crosley Div. 10
Benton & Bowles, Inc., New York, N.Y.
Baldwin-Lima-Hamilton, Loewy Hydropress Div. 79
Gray & Rogers Advertising, Philadelphia, Pa.
Brunswick-Balke-Collender Co. 61
McCann-Erickson, Inc., Chicago, Ill.
Burroughs Corp. 50-51
Campbell-Ewald Co., Detroit, Mich
Chandler Evans Corp. 11
G. F. Sweet & Co., Hartford, Conn.
Curtiss Wright Corp. 102
Adams & Keyes, Inc., New York, N.Y.
Douglas Aircraft Co., Inc. 47
J. Walter Thompson Co., Los Angeles, Calif.
Eastman Kodak Co. 45
The Rumrill Co., Inc., Rochester, N.Y.
Erco, Div. of ACF Industries, Inc. ..... 2nd Cover
de Garmo, Inc., New York, N.Y.
Experiment Incorporated 71
Eastern Advertising, Inc., Richmond, Va.
The Garlock Packing Co. 77
Hutchins Advertising Co., Rochester, N.Y.
The Garrett Corp., AiResearch Mfg. Co. 59
J. Walter Thompson Co., Los Angeles, Calif.
General Motors Research Laboratories 57
Campbell-Ewald Co., Detroit, Mich.
Government Products Group, American Machine & Foundry Co. 1
Cunningham & Walsh, Inc., New York, N.Y.
Jet Propulsion Laboratory 17
Barton A. Stebbins Advertising, Los Angeles, Calif.
Johns Manville Corp. 5
Cunningham & Walsh, Inc., New York, N.Y.
Kearfott Co., Inc. 85
Gaynor & Ducas, Inc., New York, N.Y.
Walter Kidde Co., Inc. 89
Cunningham & Walsh, Inc., New York, N.Y.
McCormick Selph Associates 7
Aircraft & Missile Consultants, Manhattan Beach, Calif.
MacMillan, Inc. 105
Franklin Spier, Inc., New York, N.Y.
Magnaflux Corp. 63
Stoetzel & Associates, Inc., Chicago, Ill.
Magnetic Amplifiers, Inc. 48
de Garmo, Inc., New York, N.Y.
Martin Co. 93, 95, 97, 99, 101, 103
Ketchum, MacLeod & Grove, Inc., Pittsburgh, Pa.
Martin Co., Denver Div. 65
E. M. Halvorson Co., Denver, Colo.
Minneapolis Honeywell, Aeronautical Div. 44
Kerker-Peterson, Inc., Minneapolis, Minn.
Minneapolis-Honeywell, Heiland Div. 74-75
Tool & Armstrong Advertising, Inc., Denver, Colo.
Minneapolis Honeywell Regulator Co. 14-15
Foote, Cone & Belding, Chicago, Ill.
Mosley Electronics, Inc. 71
H. George Bloch, Inc., St. Louis, Mo.
Northrop Corp. 49
Erwin Wasey, Ruthrauff & Ryan, Inc., Los Angeles, Calif.
Norton Co., Refractories Div. 53
James Thomas Chirurg Co., Chestnut Hill, Mass.
Parker Seal Co. 9
Lester-Voorhees Co., Los Angeles, Calif.
Pressure Products Industries, Inc. 71
Charles D. Karlsruher Advertising, Havertown, Pa.
Radio Corp. of America
Advanced Military Systems Dept. 91
Defense Electronic Products 13
Al Paul Lefton Co., Inc., Philadelphia, Pa.
Reaction Motors Div., Thiokol Chemical Corp. 55
Brown & Butcher, Inc., New York, N.Y.
Republic Aviation Corp. 81
Deutsch & Shea, Inc., New York, N.Y.
Robbins Aviation, Inc. 102
Phillips/Robbins, Inc., North Hollywood, Calif.
Rosemount Engineering Co. 80
Midland Associates, Minneapolis, Minn.
Southwest Products Co. 12
O. K. Fagan Advertising Agency, Los Angeles, Calif.
Space Technology Laboratories 2
Gaynor & Ducas, Inc., Beverly Hills, Calif.
Taber Instrument Corp. 16
The Pursell Co., Buffalo, N.Y.
Thiokol Chemical Corp. 18-19
Brown & Butcher, Inc., New York, N.Y.
H. I. Thompson Fiber Glass Co. 67
Van der Boom, Hunt, McNaughton, Inc., Los Angeles, Calif.
United Aircraft Corp., Research Laboratories 69
B. E. Burrell & Assoicates, Hartford, Conn.
Vickers, Inc. 82
Gray & Kilgore, Inc., Detroit, Mich.